An Operational Review of Air Campaign Planning Automation

THESIS

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AFIT/ENS/GOA/98M-04

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Presented to the Faculty of the Graduate School of Engineering of the Air Force Institute of

Technology Air University In Partial Fulfillment for the Degree of

Masters of Science in Operations Research

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March, 1998

Sponsored in part by HQ ACC/XP-SAS.

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Acknowledgments

I am indebted to Dr. James W. Chrissis and Major Raymond R. Hill Jr., for agreeing to advise me on this project. Their insight and guidance during this research effort were invaluable. They provided guidance and motivation without limiting my research topic. This project would not have been possible without the efforts of Mr. William Cotsworth, President AEM Services, Incorporated. He was extremely generous and patient in explaining the intricacies of the Conventional Targeting Effectiveness Model. His interest in this research was a constant source of motivation. Thanks to each of you. Finally, I would like to thank my wife, Jeannette, and my two children, Caitlin and Rachel, who provided unwavering support and patience during the thesis process. Without their encouragement this thesis would not have been accomplished.

William R. Haas

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English Symbols

Symbol	Definition
CCUBE	Probability of successful command and control in passing fire message
CDE	Compound Damage Expectancy
DE	Damage Expectancy
DIF	Positive difference between what the goal achieved and the value desired
IMPTDEFLEAK	SEAD corrected single shot leakage of the defense against the defined weapons
M	Penalty value
N	Number of weapons expended
PA	Probability of arrival
PLS	Estimated pre-launch survivability for a specified base for a specified side
PSSK	Probability of a single shot kill
PTP	Reliability degradation factor relating to a carrier's general probability of penetration
STRAT	Number of strategies
TDEFLEAK	Single shot leakage of the defense against the define weapons
TSURV	Survivability of a specified target class on a specified side
V	Value of target k or goal g

Subscripts

Symbol	Definition
i	Aircraft type
j	Weapon type

k	Target type
s	Strategy-unique aircraft/weapon/target combination
g	Goal

Abbreviations

Abbreviation	Definition
ABP	Air Battle Plan
ACO	Airspace Coordination Order
ACPT	Air Campaign Planning Tool
ADS	Airspace Deconfliction System
AFIT	Air Force Institute of Technology
AOC	Air Operations Center
AOR	Area of Responsibility
APS	Advanced Planning System
ATO	Air Tasking Order
AUTODIN	Automatic Data Interchange Network
BDA	Battle Damage Assessment
BEN	Basic Encyclopedia Number
CAFMS	Computer Assisted Force Management System
CAFWSP	Combat Air Force Weather Support Program
CAP	Combat Air Patrol
CDE	Compound Damage Expectancy
COG	Center of Gravity
CS	Constant Source

CTAPS	Contingency Theater Automated Planning System
CTEM	Conventional Targeting Effectiveness Model
DARPA	Defense Advanced Research Projects Agency
DE	Damage Expectancy
DMPI	Desired Mean Points of Impact
EC	Electronic Combat
EI	Effectiveness Index
EOB	Electronic Order of Battle
GAT	Guidance, Apportionment and Targeting
HQ	Headquarters
HVAA	High Value Airborne Assets
ICM	Intelligence Correlation Module
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
IMOM	Improved Many on Many
INTSUMS	Intelligence Summaries
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JIPTL	Joint Integrated Prioritized Target List
JMEM	Joint Munition Effectiveness Manual
JPT	JFACC Planning Tool
JTCB	Joint Targeting and Coordination Board
KTO	Kuwaiti Theater of Operations
MAAP	Master Air Attack Plan

MAP	Master Attack Plan
NCA	National Command Authority
NTC	Night Target Cell
OB	Order of Battle
ODS	Operation Desert Storm
PD	Probability of Damage
PGM	Precision Guided Munition
QDR	Quadrennial Defense Review
RAAP	Rapid Application of Air Power
REM	Route Evaluation Module
SEAD	Suppression of Enemy Air Defenses
SPINS	Special Instructions
SSPD	Single Shot Probability of Damage
STT	Strategy to Task
TNL	Target Nomination List
TOT	Time on Target
TPW	Target Planning Worksheets
USAF	United States Air Force
VFR	Visual Flight Rules
WEB	Weapons Effects Database
XIDB	Standard Extended Intelligence Database
XOOC	Checkmate Division of the Air Staff

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Abstract

Operations research has been applied to air campaign planning with mixed results. Air campaign planning is a complex process that is combinatorial by nature. It requires a plethora of decisions by weapons systems experts in a dynamic environment and current processes require approximately 48 hours of planning for each 24 hour period of the campaign. It is as much an application of military art as military science. The Contingency Theater Automated Planning System (CTAPS) applies some automation to many of the processes in air campaign planning. However, the key input into CTAPS, the master air attack plan (MAAP), was still a manual process in Operation Desert Storm. It is believed the entire planning process can be shortened and made more responsive by applying automation to MAAP building. The Joint Force Air Component Commander (JFACC) Planning Tool (JPT) was developed by Headquarters United States Air Force/XOOC (Checkmate). JPT uses the Conventional Targeting and Effectiveness Model (CTEM) as the force analysis tool to aid in MAAP building. CTEM is a mathematical model using linear programming and goal programming techniques to allocate weapons and aircraft to targets.

Mathematical models such as CTEM, to be computationally tractable, several assumptions and limitations must be made. This thesis reviews these assumptions from both an operational and operations research point of view. It is critical that expert planners understand these limitations when considering the options presented in the models solution.

In an effort to give the experts more control over the model, a new approach is being developed, collaborative planning. This thesis reviews a pre-production version of collaborative planning software, developed by AEM Services, Inc., for Checkmate, called ADVISE. Collaborative planning appears to represent the future of MAAP automation.

An Operational Review of Air Campaign Planning Automation

Chapter 1 - Background and Statement of the Problem

The fundamental tenet of aerospace power is centralized planning and decentralized execution. Centralized planning is key to coordinating efforts among all available forces while decentralized execution makes it possible to generate the tempo necessary to accomplish the objectives of the Joint Force Commander (JFC) [14]. The JFC can appoint a Joint Force Air Component Commander (JFACC) who is responsible for the centralized planning of the air campaign. The JFACC attempts to translate the JFC's objectives into an air campaign that supports those objectives. The air campaign is coordinated through the use of the Air Tasking Order (ATO) [3, vi]. The ATO is the planning structure that provides the detailed direction to air forces and enables the JFACC to synchronize air attacks for the maximum effect on the enemy in the most efficient manner while reducing the risk of fratricide [11, 11].

Air campaign planners must gather and analyze information from multiple and varied sources to generate an ATO; it is a complex and time consuming process. The current ATO cycle takes 48 hours of planning by multiple tactical experts for each day of execution. Critics of this current ATO process carried out in accordance with Joint Pub 3-56.1 claim the planning process is too inflexible; it cannot adjust to changes based on battle damage assessment (BDA), in-flight reports, or the ground commander's changing requirements [14]. In reality, a balance must be struck between two competing goals. The process must balance the need for an effective, well-ordered, deliberate planning process against the capability to change target priorities and attack new high-priority targets as quickly as possible [11, xiii].

The United States Air Force (USAF), through on-going research, is seeking methods to expedite and "optimize" the air campaign planning process. RAND, a nonprofit institution that helps improve public policy through research and analysis, believes automating the master air attack plan (MAAP) development can significantly speed up the ATO generation process [11, 27].

1.1 Problem Description

Tactics can be defined as the application of analytical knowledge applied artistically to accomplish a specific objective or set of objectives. The complexity of the analytical data, number of variables involved and the problem of trying to accurately model "operational art" make automation of air campaign planning very difficult. Every simplifying assumption limits the decision space considered and reduces the range of viable solutions presented by the model. This is contrary to advice imparted by Air Force Manual 1-1 which counsels, "Planners should examine the full range of available air and space assets when selecting the systems required to achieve the objective of the campaign" [2, 126].

The U.S. military is moving toward more modeling and simulation to analyze and solve problems. The recent Quadrennial Defense Review (QDR) relied heavily upon modeling and simulation to determine the future force structure of the U.S. armed forces. The lack of adequate modeling and simulation capability was listed as a limiting factor in the QDR [13].

However, it is not an easy task to develop computer-aided planning that can adequately replace the current manual tactical-expertise approach. The tools used to automate air campaign planning have been primarily mathematical models. The analyst and air campaign planner must understand the assumptions of the model and their effect on the solution space. Tactical experts must understand the operation of all models. The campaign planner must have faith in the tool or it will not be used.

Effective use of an automation tool requires the planner to understand the operational impact of the restricted solution space.

The key element of the air campaign is the MAAP. It is the translation of the objectives into military actions that work to accomplish the objectives. It is the key input to building the daily ATO. MAAP building is an area where mathematical models may provide useful automation support. The problem then becomes, are the current models used to aid in air campaign planning automation adequate?

The purpose of this thesis is to examine the current air campaign planning aides and assess the tactical limitations the optimization software places upon solution space coverage. The pilot-planner must understand what assumptions and limitations are inherent in automation tools in order to effectively use such tools. This thesis examines the leading edge air campaign planning aides and how they fit into the planning process as well as an analysis of the MAAP optimization routines.

1.2 Research Issues

The JFACC planning staff is composed of experienced field-grade combat aircrews. Most are experts in air combat weapon systems employment. Any attempt to analyze the operational limitations created by the simplifying assumptions of modeling processes requires a thorough knowledge of weapon systems employment and the ergonomics of air campaign planning. The author brings these qualities to the research as a graduate and former instructor of the premier tactics school in the USAF, the USAF Weapons School.

This thesis reviews the current advancements in the air campaign planning process. Specifically, the Defense Advanced Research Projects Agency (DARPA) and Headquarters (HQ) USAF/XOOC (Checkmate) developed the Air Campaign Planning Tool (ACPT), (now known as the JFACC Planning Tool, JPT), as a JFACC decision aid. The JPT employs a strategy-to-task (STT) approach to

link the high-level military, political, economic and foreign policy objectives to the JFC's campaign objectives. The campaign objectives are used to derive the air campaign objectives and finally the air campaign plan. The JPT produces a Master Attack Plan (MAP) based on an optimal weapons allocation model called the Conventional Targeting and Effectiveness Model (CTEM) [11, 43-44]. This thesis analyzes the simplifying assumptions in CTEM and details the operational limitations implied by these assumptions.

Additionally, JPT limits the inputs to CTEM and further restricts the solution space. Many of CTEM's input variables are preset to simplify model use. However, these preset variables limit the range of solutions. The operational impact of these restrictions are examined as well.

The USAF has invested significant effort into developing air campaign planning aids to optimize and expedite the planning process, since it is an important force multiplier that can potentially make or break an air campaign. The joint standard for development and dissemination of the ATO is the Contingency Theater Automated Planning System (CTAPS) [3]. A review of CTAPS is important for understanding the current tools used in air campaign planning.

Finally, this thesis examines the idea of collaborative planning as a technique to overcome the limitations of mathematical modeling and simulation. Collaborative planning gives the expert the capability to insert corrections into the model based on operational or tactical assessments.

The underlying goal of this thesis is to bring the current work on ATO generation into a single document and provide an operator's perspective combined with an operations analysis background on the applicability of the approach taken to expedite and optimize the ATO.

1.3 Methodology

The approach to this research is divided into three parts. The first part examines the nature and characteristics of planning an air campaign. The second part analyzes CTEM, and CTEM

within JPT. The third part examines the future advancements anticipated in the MAAP automation processes.

1.3.1 Part I

Part one examines the Air campaign planning processes. It reviews the five theoretical phases of the air campaign planning process: operational environment research, objective determination, strategy identification, centers of gravity identification, and the joint operations plan development. Any analysis of the tools used in campaign planning requires a thorough understanding of the information flows and tasks required in planning an air campaign.

An integral part of the current air campaign planning process is the tools available to assist the planner. The current tools are a collection of software and hardware called CTAPS. A review of the planning aids provided by the CTAPS architecture provides the reader the background information on the current state of automation tools.

Finally, part one examines how the air campaign in Operation Desert Storm actually worked. It discusses ATO information flows, time-lines, decision points, problem areas and possible areas of improvement such as MAAP automation.

1.3.2 Part II

The power of the force analysis in the JPT is contained in the CTEM. CTEM is a complex force analysis model with significant flexibility but, like any mathematical model, CTEM makes assumptions which carry into building a master attack plan. These assumptions are identified by examining the objective function and constraints of the optimization routines as well as the preprocessors and post-processors of the model.

Once the assumptions are identified, operational limitations implied by the assumptions are enumerated. The interface of JPT with CTEM also produces some restrictions on the MAAP and these additional assumptions are analyzed from an operational perspective.

1.3.3 Part III

Finally, part III reviews the case for collaborative planning; it discuses the reasons why the approach may be the solution to automated MAAP building. The section ends with an examination of the new, state-of-the-art collaborative planning software, called ADVISE, being developed for JPT.

Chapter 2 - The Air Campaign Planning Process

In order to understand how the automation tools for air campaign planning aid the planning process, it is important to understand the development of the air campaign. Planning an air campaign starts with understanding the joint force mission as defined by the National Command Authority (NCA). The JFC's strategic appraisal of the political, economic, military and social forces affecting the area of responsibility (AOR) and the development of strategic and operation objectives form the basis for determining the air campaign objectives. The air campaign objectives must support the JFC's overall campaign objectives while retaining the flexibility necessary to adjust to the dynamics of the range of military options [3, III-1].

Air campaign planning entails making choices. Planners must choose the proper objectives and the correct strategy to accomplish those objectives. This means applying one's strengths against an enemy's weaknesses by identifying the proper centers of gravity (COG). The COGs are attacked by choosing a suitable weapons system against the right target in the right sequence [15, 21-22]. These choices require a carefully selected joint staff of planners and weapons systems experts facilitating consideration and understanding of all component capabilities and forces [3, III-2]. These experts are operators of their respective weapons or support systems, and are well-versed in current employment tactics. Such an approach follows Air Force doctrine. According to Air Force Manual 1-1

"Because of their specialized competence, airmen must play a key role in the employment of aerospace. Their role begins with the advice they provide to the combatant commander on what aerospace forces are needed and how those forces should be employed" [2, 126].

It is critical for the experts and analysts to understand the air campaign planning process and where the automation tools are applied to aid in making many of the complex decisions. This chapter presents a review of the air campaign planning processes. First a review of the five theoretical phases of air campaign planning followed by a description of the current planning tools included

in the CTAPS architecture. The chapter concludes with an examination of Operation Desert Storm as an example of a large-scale air campaign. How the planning process actually worked, problems with the processes and areas of improvement are discussed.

2.1 Theoretical Phases of the Air Campaign Planning Process

Normally there are five phases in the air campaign planning process:

- researching the operational environment,
- determining the air objectives,
- identifying the strategy to accomplish the objectives,
- identifying centers of gravity,
- putting the plan together.

The campaign planner does not necessarily accomplish these phases in sequential order. The completion of one phase is not necessary to begin another. Even though the phases build upon one another, they also overlap each other and continue to provide information for refinement of the process and product [3, III-2].

2.1.1 Operational Environment Research

Researching the operational environment primarily produces the intelligence preparation of the battle-space.. It is the gathering of in-depth knowledge of the operational environment. This includes knowing an enemy's capabilities, disposition, and intentions as well as one's own capabilities. It requires knowledge about the environment, logistics, political-military alliances, history and culture [3, III-4].

2.1.2 Objective Determination

The campaign planner must produce clearly-defined and quantifiable objectives. The objectives are derived from the JFC's objectives and contribute to the accomplishment of the JFC's theater objectives [3, III-4]. In this case quantifiable means *measurable* or *having some way of knowing* if the executed military action achieved the objective. This relates back to operational environment

research and finding the information needed to measure the success of the objectives, in this case BDA. The objectives must be achievable. Many factors can limit the range of the objective. There are limits to what airpower can achieve. Airpower can be limited by time, politics, availability of forces, weather, environment and even culture. As examples, area bombing of Germany during World War II failed to lead to the overthrow of Hitler, and the bombing campaign on the Iraqi command and control system never led to the overthrow of Saddam Hussein as theorized by the campaign planners [10]. Much evidence exists to suggest that airpower is unable to affect political stability or a population's will to fight, and therefore such objectives are not achievable. Once the objectives are determined, the strategy to accomplish the objectives is identified.

2.1.3 Strategy Identification

The air campaign plan must clearly articulate how the available air power can achieve the air objectives. The "how" is the air strategy [3, III-4]. The strategy must achieve the objectives sought and it must apply to the situation at hand. The campaign planner wants a strategy that applies their strengths against their enemy's weaknesses. An example would be taking advantage of a technological superiority to fight at night [15, 19-20]. The strategy clearly depends on the information from the operational environment research, the commander's intent and the air objectives. However, for the objectives to be achievable, they must be constructed with some thought to the strategies available. Clearly, the first three phases are closely intertwined and as the phases proceed they become more specific and detailed.

2.1.4 Centers Of Gravity Identification

Joint doctrine defines COGs as "those characteristics, capabilities, or localities from which a military force, nation or alliance derives its freedom of action, physical strength, or will to fight" [4, 65]. Campaign planners must identify those COGs whose defeat helps achieve stated objectives.

Identifying the COGs is a complex and comprehensive task. The objectives and strategy must be clearly understood and the environment carefully researched [3, III-5]. One aspect that makes this phase of planning so complex is all the possible considerations that must take place. Another difficulty in determining an enemy's COGs is identifying the most critical capabilities of the enemy to attack. Not all cultures think like us and have value systems similar to our own [15, 20]. Therefore, researching the operational environment must include a study of the enemy's value systems. The enormous number of possibilities is considered the greatest barrier in the selection of the appropriate COGs [3, III-5].

The type of COG and method of attack can vary widely with the range of military operations. COGs may be attacked directly or indirectly. Attacks on COGs may be hampered by political considerations, military risks, laws of armed conflict, and rules of engagement. Single targets, target systems, or multiple, interrelated targets may represent COGs and these may have to be attacked in sequential order or simultaneously. It may be necessary to attack any defenses around COGs in order to expose the COG to vulnerability. Once the COG is identified, a sufficient amount of force is applied to achieve the JFC's objective, consistent with the laws of armed conflict [3, III-5-III-6]. All of these considerations create a complex web of relationships and decisions that make air campaign planning very difficult. The COGs are inextricably linked to the objectives strategy and the operational environment research. However, it is not a purely sequential process; the objectives and strategy cannot be determined in a vacuum without some knowledge of the enemy's vulnerabilities or their COGs.

2.1.5 The Joint Air Operations Plan Development.

The final phase of air campaign planning takes the information and decisions from the previous phases and builds a detailed plan directing how the air campaign is to support the JFC's operation.

This includes a phased approach integrated into the JFC's overall campaign plan. During this phase targeting and tasking match forces and weapons to targets in the sequence necessary to achieve the desired objectives.

2.1.5.1 Targeting

Targeting is a cyclical process based on the objectives, strategy and COGs determined in the previous phases of the air campaign planning. The planner determines which targets to attack, and in what order, to achieve the stated objectives. The appropriate level of destruction or degradation is determined for each target. Many factors complicate targeting such as: threats to friendly forces, deconfliction from duplicate targeting, and synchronization with other forces or components [3, IV-1]. All these factors continuously change causing each subsequent targeting cycle to be as complicated as the previous cycle. BDA and intelligence updates provide feedback and new targets are identified while planners determine which previously-struck targets must be attacked again and thus reenter the targeting cycle (Figure 1).

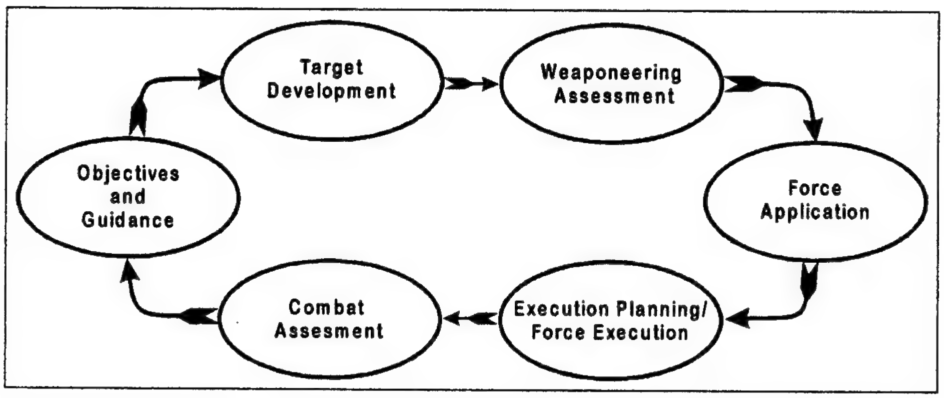

Figure 1. Targeting Cycle

The planner chooses targets to inflict the desired level of degradation on the enemy's COGs and the weapons and forces to deliver those weapons based on location, threats, weather, time of day, and so on. Once tasked and executed the results of the strike must be determined as this affects

the next targeting cycle depending on the JFC's priorities. The planners must determine if the phase objectives have been accomplished by the strike and if not, what COGs need to be struck again or added to the target list. The priorities could change depending on the enemy's reaction.

As examples, during Operation Desert Storm two significant deviations in the planned execution of the air campaign occurred. The first was the diversion of air resources to attack SCUD missiles. The second was targeting Iraqi hardened aircraft shelters when the Iraqis moved to protect their Air Force [10, 2]. In both of these examples, the enemy's reaction to the previous attacks caused a change in the JFC's priorities. The first for political reasons and the second for military reasons. The tasking cycle (Figure 2) closely resembles the targeting cycle.

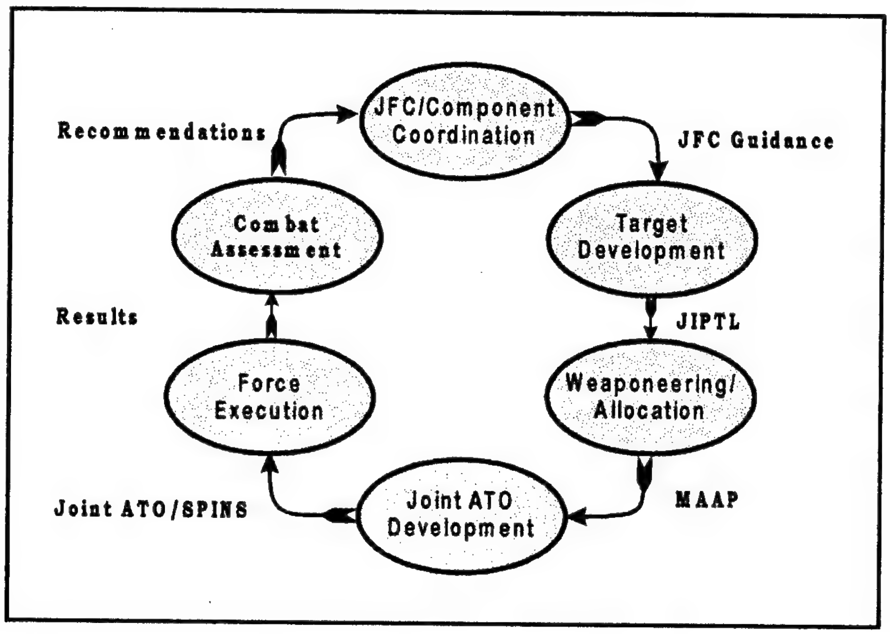

Figure 2. Tasking Cycle

2.1.5.2 Tasking

The joint tasking cycle provides a repetitive process for planning, coordinating, allocating and tasking joint air missions within the guidance of the JFC. It is an analytical and systematic approach

that focuses targeting efforts on supporting operational requirements [3, IV-4]. The product of the tasking cycle is the ATO. The ATO is the document that provides the detail to the pilot at the unit level for actual execution of the plan. The notional 48 hour time-line of the ATO cycle is shown in Figure 3. The plan is executed on the third day.

It is in the tasking cycle that planners determine which specific target is attacked by which weapons systems. It is believed that automation can reduce the time required to complete a tasking cycle. The phases of the tasking cycle are

- JFC/Component Coordination,
- Target Development,
- Weaponeering/Allocation,
- Joint ATO Development,
- Force Execution, and
- Combat Assessment.

Phase 1: JFC/Component Coordination

The JFC consults with component commanders to determine the strategic direction future plans should take based on assessment of previous results. Targeting priorities are identified and the air apportionment is determined. Air apportionment allows the JFC to ensure the weight of effort is consistent with the campaign phases and objectives. Again the campaign objectives drive this coordination, meaning clearly defined objectives are essential to the proper execution of the campaign [3, IV-7].

Phase 2: Target Development

Target development is based upon the guidance received in phase 1. Targets nominated for strike support the targeting objectives, the air campaign objectives, and priorities supplied by the JFC. Planners select targets from joint target lists, component requests, intelligence recommendations, electronic warfare inputs, and current intelligence assessments according to the situation. The end product is a prioritized list of targets, the joint integrated prioritized target list (JIPTL) [3, IV-7].

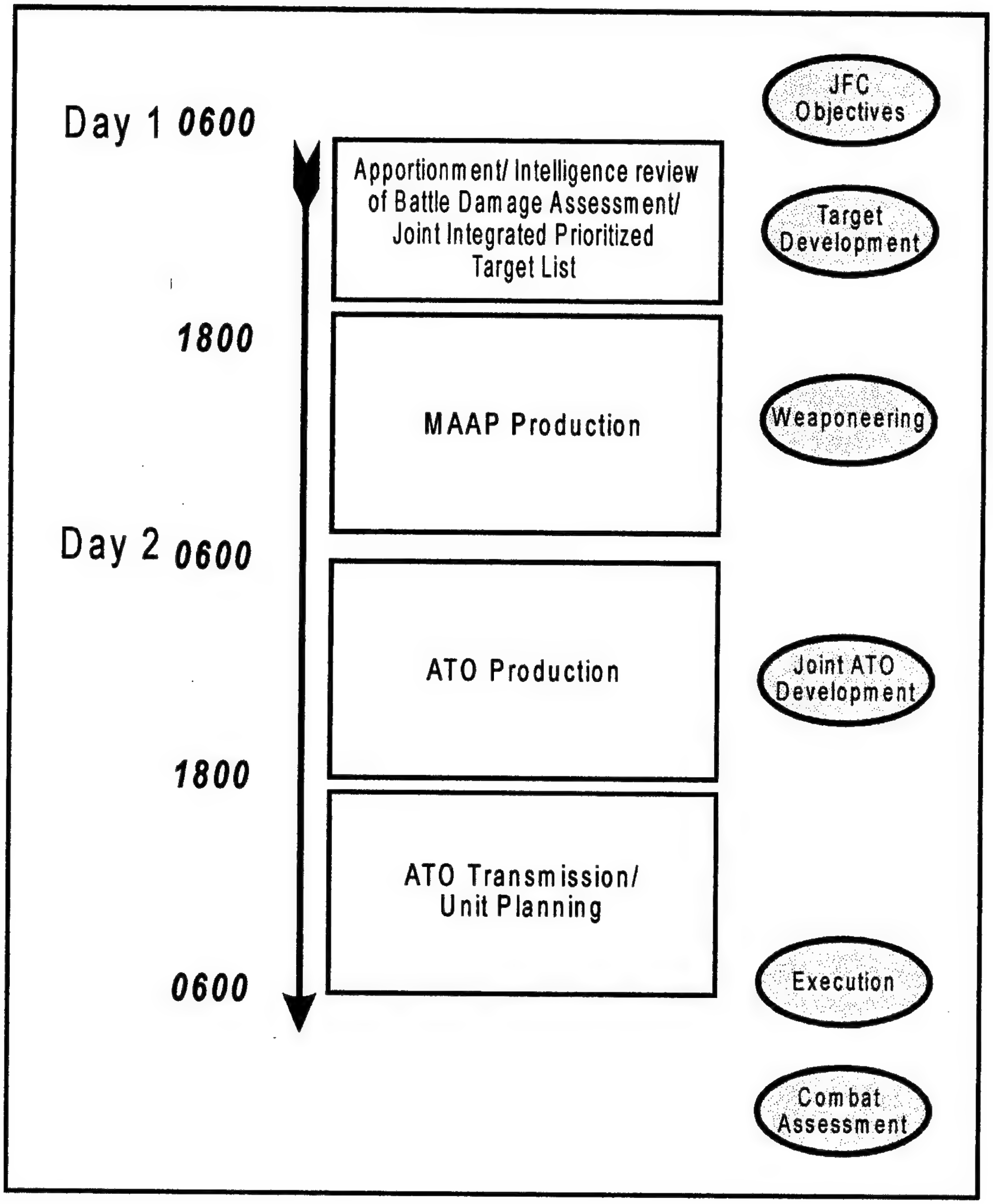

Figure 3. Notional ATO Timeline

Phase3: Weaponeering/Allocation

The JIPTL provides the basis for the weaponeering activities; targeting personnel quantify expected results of lethal and nonlethal weapons against prioritized targets. Targeteers provide detail on recommended aimpoints, number and type of aircraft, weapons fuzing, target identification and description, target attack objectives, threats in the target area, and the probability of destruction. The final prioritized targets are then included in the MAAP. The MAAP is the foundation of the joint ATO [3, IV-8].

Phase 4: Joint ATO Development

The MAAP is reviewed and approved by the JFACC. Work continues on the special instructions (SPINS) and the airspace coordination order (ACO). The SPINS provide more detail on specific missions. For example, the SPINS may contain the specific routing a mission must fly for safe passage. The level of detail can be very explicit when forces operate from different bases and multi-component or composite missions are tasked. The ACO deconflicts the airspace for special-use purposes and travel to and from the target areas. This phase provides the detail needed by the pilots to execute their missions within the guidance specified by the JFC [3, IV-9].

Phase 5: Force Execution

Even after the execution order has been given, the ATO can be changed to meet changing requirements. This is not the ideal situation, but the enemy does not always react in the ways predicted and adjustments must be made to meet changing requirements. All changes to tasking must be coordinated and deconflicted with the appropriate control agencies or components [3, IV-11].

Phase 6: Combat Assessment

Effective planning and execution requires a continual evaluation of the impact of the force execution on the overall campaign plan. It is the feedback from the current plan that closes the tasking cycle, and provides critical inputs to subsequent cycles. Planners require input on the success of their

plans in order to properly guide the air campaign to the desired overall conclusion. This input comes from BDA and continued intelligence gathering. Conjectured enemy courses of action and capabilities need to be weighed against JFC and JFACC targeting priorities to determine future targeting objectives and reattack recommendations [3, IV-11], and thus the cycle is complete.

2.2 The Contingency Theater Automated Planning System

The Theater Contingency Automated Planning System (CTAPS) is the joint standard ATO generation and dissemination software [3, IV-12]. CTAPS is a complex combination of applications modified to run together in the same client-server computing environment [11, xiv]. Reviewing CTAPS 5.0x application modules provides necessary background information on the current ATO automation tools.

2.2.1 Airspace Deconfliction System (ADS)

The ADS produces an ACO. The ACO divides the airspace into usable geographic areas for travel to and from the area of operations (AO), air refueling, base defense zones, weapons free zones, restricted operating zones, and weapons engagement zones. The ADS constructs these air routes, exclusion zones, and combat zones and can overlay them on a map using the common mapping system [11, 35-36].

2.2.2 Advanced Planning System (APS)

APS provides automation of air battle planning and ATO generation. Developed by Rome Laboratory, APS is one of the more complex modules in CTAPS and provides automated planning tools for strike, tanker, reconnaissance, escort, ground alert, and orbiter missions. Orbiter missions include defensive counter air, combat air patrol, and surveillance missions where specific orbit locations are assigned. APS' primary functions include ATO management, data import, database management, and air battle planning [11, 36].

2.2.2.1 Data Management

APS can mange a full set of ATOs. It can create, modify or delete ATO databases. The APS can also archive past ATOs. Additionally, APS can import scenario data from other CTAPS mission modules. Table 1 lists the data APS can import and the corresponding source module [11, 37].

Table 1. APS Data Import Capabilities

DATA	Source
Enemy Order of Battle	Intelligence Correlation Module
Equipment	Intelligence Correlation Module
Coordination/Rendezvous Points	Airspace Deconfliction System
Airspace Control Zones	Airspace Deconfliction System
Target Nomination List/ Weaponeering Options	Rapid Application of Air Power

The APS also uses a number of databases to store the information required for the automation tools. Three layers of data are in the air battle plan (ABP): theater data, scenario data, and ABP data. Theater data is usually fixed and rarely changes during the course of a short conflict. It is entered into the system before ATOs are prepared. Theater data includes items of equipment such as aircraft, missiles and radar that are in theater. Table 2 shows a list of theater data types [11, 36-37].

Table 2. APS Theater Data Types

Aircraft Types	Missile Equipment
Mission Types	Jammer Equipment
Standard Conventional Loads	Radio Equipment
Radar Equipment Air Bases	Digital Map Data

The second layer of data is scenario data which typically changes daily. For example, logistics type data may include munitions availability and guidance data results from the JFC coordination and apportionment decisions. Table 3 illustrates the type of data that is considered scenario data [11, 37]. As the scenario data changes, the appropriate CTAPS databases must be updated. This changing data can have serious impacts on the developing plan.

Finally, the ABP data is specific to a single ATO. It includes data such as target assignments and package assignments for specific aircraft. The data changes daily, but may also change more frequently as changes to the ATO are made [11, 37].

Table 3. APS Scenario Data Types

Logistics Intelligence Targets Airspace (ACO)	Weather Guidance Tactical Data

2.2.2.2 Air Battle Planning

The air battle planning function of the APS models six types of aircraft missions: target, reconnaissance, tanker, orbiter, escort, and ground alert. The user can arrange the detail of strike package coordination through on-screen worksheets. Information such as tanker location, call sign, and identification friend or foe (IFF) codes are assigned to aircraft using the worksheets. The APS has a deconfliction tool which automatically checks the timing assumption for each air mission based on aircraft speeds, routes, time on target (TOT), and other data. The system issues a feasibility warning message if it detects a contradiction in mission timing [11, 37].

2.2.2.3 Other APS Automation Aids

Other APS automation aids include an autoplanner, route planning tool, and electronic combat (EC) analysis tool. However, planners often use other CTAPS mission applications instead of the APS tools if higher fidelity is needed because the other applications can provide better results. The graphics-intensive EC and route planning tools slow the planning to an unacceptable level [11, 37].

The APS Autoplanner can assign tankers to aircraft, assign aircraft to targets, and perform nearly all calculations necessary to complete an ABP. However, the calculations are based on simple

routes based on only the minimum number of way points dictated by the ACO. The Autoplanner assigns missions to targets based on a weighted priority system that is entered beforehand [11, 38].

A limitation of the autoplanner is that it was originally optimized to finish planning already started. It was not designed to start the planning process. However, the APS does have a relatively user-friendly graphical interface that allows the planner to open windows of information and create new strike missions by "point and click operations" [11].

2.2.3 Computer Assisted Force Management System (CAFMS)

CAFMS was originally designed as stand-alone automation system with its own hardware to support the Combat Plans Division and the Combat Operations Division of the Air Operations Center (AOC). CAFMS was used during the Gulf War for ATO production and dissemination. However, the software was hosted on obsolete hardware and numerous difficulties were encountered with the system during Operation Desert Storm. Transmission times of the ATO were excessive and incompatibilities existed between branches of the armed forces. Early in the war the United States Navy had to fly in the ATO to get a copy in a reasonable time. CAFMS was upgraded for use with CTAPS 5.0x, but it is being phased out in CTAPS version 6.0. The function of CAFMS is to collate the ATO; it combines the ACO, ABP and SPINS into a standard format, checking for formatting errors, for transmission via the Automatic Data Interchange Network (AUTODIN) [11, 38].

CAFMS is also a database management tool. Planners can use CAFMS to access the ATO database to determine which aircraft are on alert, what targets are going to attacked in the next hour, or which aircraft can be diverted if necessary. These capabilities allow CAFMS use for real-time battle management [11, 38].

Finally, CAFMS is used to update databases on aircraft, munitions, air defense weapons, communications circuits, and air crew status. The air crew mission reports are input into CAFMS for transmission back to the AOC to update intelligence, targeting, and logistic databases [11, 38-39].

2.2.4 Combat Air Force Weather Support Program (CAFWSP)

Planners use the CAFWSP to display and import a variety of weather data. Planners can view current forecast weather maps, areas of cloud cover, visual flight rules (VFR) areas, and areas requiring instrument flight rules (IFR). CAFWSP also stores and displays visibility, wind and precipitation data, as well as airbase weather observations and forecasts [11, 39].

2.2.5 Intelligence Correlation Module (ICM)

The function of the ICM can be surmised from its name. Planners use the ICM to quickly search order of battle (OB) databases according to location, equipment, type of facility, military units, or other key words. ICM operators preload the module with parts of the standard extended intelligence database (XIDB) information before deployment. Friendly OB data such as aircraft, ground forces, facilities, installations, and electronic OBs can also be maintained by ICM. The CTAPS CMS is used to display the OB data [11, 39].

Several limitations to ICM version 1.0 exist. The databases are updated manually. The ICM also does not have an automated interface with any real-time intelligence dissemination system like Constant Source (CS). Another limitation is the inability of the current ICM to receive or process imagery. ICM communication interfaces are limited to the CTAPS AUTODIN communication modules. AUTODIN messages must conform to the U.S. Message Text Format (USMTF). Planners can use the CTAPS AUTODIN communications suite to transmit intelligence reports to external agencies and units, and it can also receive intelligence reports from external sources. Any information relating to the OB databases is entered manually [11, 39].

Although not having good access to real-time intelligence, the ICM can share its information with many of the other CTAPS applications. The ICM does interface with the Improved Many-on-Many (IMOM), and can receive and display electronic OB (EOB) generated by IMOM. The ICM can transmit the OB databases directly to the Rapid Application of Air Power (RAAP) application of CTAPS. Finally, the ICM can interface directly and share Intelligence Database with the unit-level intelligence system, Sentinel Byte [11, 39].

However, the sharing of information in this case means the information can be forwarded to the other modules, but the databases are not linked. To update the information in the other databases, the entire OB database is transferred or the changes are entered manually. If the databases are large, as they frequently are, the process of sharing information becomes very time consuming. In a dynamic military environment, keeping the databases synchronized is difficult. If different AOC divisions are operating on different OB databases, the planning process can break down [11, 74-75].

2.2.6 Improved Many-on-Many (IMOM)

IMOM is an electronic combat assessment tool used to determine geographic threat coverage. It can incorporate the effects of multiple jammers, radars, and aircraft. Through the use of relatively high-fidelity simulations of multiple threat EC environments, planners can use IMOM to assist in route planning, strike package planning, and EC planning [11, 40]. IMOM can determine minimum risk routing, or which threats are protecting which targets based on a given penetration altitude. It aids the planners in determining which threats to target to improve the probability of success of the relevant missions.

2.2.7 Rapid Application of Air Power (RAAP)

Planners use the RAAP for target development and weaponeering. The RAAP application can operate as a stand alone system which allows for increased security levels or as a CTAPS mission

application limited to the secret level. RAAP provides automation support the following targeting functions:

- Target identification and characterization,
- Vulnerability analysis and aim point selection,
- Weaponeering,
- Target nomination, and
- Bomb damage assessment.

2.2.7.1 Target Identification and Characterization

RAAP manipulates a variety of targeting information that the intelligence analyst uses to identify and characterize targets. RAAP accepts text based target reports, Intelligence Summaries (INTSUMS), and a several imagery-based targeting products. Imagery sources include LANDSAT or SPOT imagery and other national imagery sources. The RAAP also produces two-dimensional digitized drawings the analyst can use [11, 40].

The RAAP application maintains the CTAPS master target database. It maintains data on the status, position, cover, definitions, and relative priority of all targets of strategic importance. Planners can import a full range of OB data from the ICM , but it can only import the entire database. Updates to the data cannot be imported automatically from the ICM in current versions [11, 40].

2.2.7.2 Vulnerability Analysis and Aim Point Selection

Planners can use the imagery imported into RAAP to identify the vulnerabilities of the different strategic targets. The analysts then choose the desired mean points of impact (DMPI) for the target. The current version of RAAP allows only five DMPIs per target [11, 41].

2.2.7.3 Weaponeering

Planners use the on-line version of the Joint Munition Effectiveness Manual (JMEM) in the RAAP application to weaponeer targets. However, the current version allows for the modeling of single weapon attacks and only allows the planner three weaponeering options per target. These

limits usually have little impact when weaponeering simple targets, but can make the weaponeering of complex targets difficult. Removing the limitations would give the planners more attack aircraft options to choose from and would increase the flexibility of ATO production [11, 41].

2.2.7.4 Target Nomination

The production of a fully weaponeered target nomination list (TNL) is one of the primary functions of the RAAP. The planners transfer the TNL to the APS where the TNL then serves as the basis for ATO production [11, 41].

2.2.7.5 Bomb Damage Assessment (BDA)

Planners produce limited support to the BDA process by adding BDA entries to the targets in the master target database. In this way a history of the target can be maintained [11, 41].

2.2.8 Route Evaluation Model (REM)

Planners use REM for route planning. It is a specialized CTAPS application that can automatically accept IMOM data. Planners use it interactively to plan ingress and egress routes for threat avoidance. REM results are used by the force-level planners only and the results are not passed to the unit level. The units use other more precise route planning systems tailored to the capabilities of the particular aircraft [11, 41].

2.2.9 Summary

CTAPS is a collection of applications that have been modified to run together with minimum interference. Many of the applications were designed as stand-alone applications and therefore have their own independent database. There are six separate OB databases and five separate target databases in CTAPS 5.0x. Synchronization and transfer of these databases creates problems.

The major applications involved in the ATO development subprocesses are shown in Figure 4. Automatic transfer of the databases from one application to the next can only be accomplished

by transferring the entire database. In a large-scale modern air campaign, this problem becomes excessively time consuming and forces the planners to accomplish the subprocesses serially. As with most serial processes, bottlenecks occur. Eliminating these bottlenecks is the target of opportunity in the automation of air campaign planning.

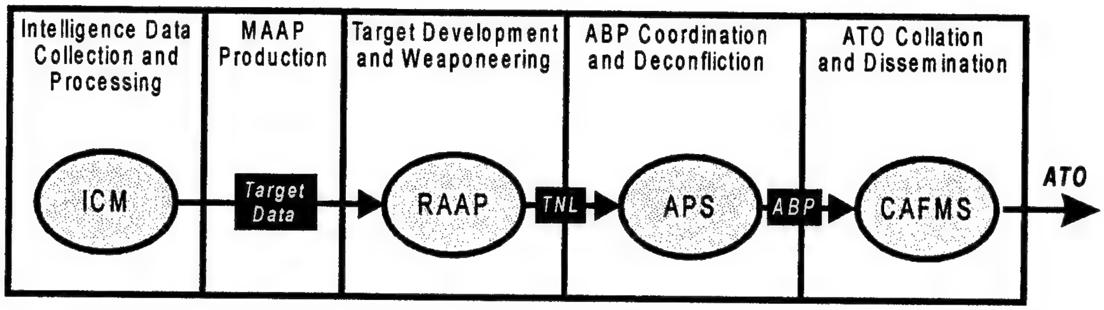

Figure 4. Key Applications and Data Flows in CTAPS

2.3 The ATO Cycle in Operation Desert Storm

Operation Desert Storm (ODS) is the most recent large scale air campaign undertaken by the U.S. A study of the lessons-learned from the Desert Storm air campaign reveals areas of the air campaign planning process and tools that require improvement. This section examines the actual ATO information flows, the time-line, and decision points from ODS. Then it examines the weak areas of the ODS ATO cycle and addresses how they might be improved.

2.3.1 ATO Information Flows

Planners produced the ATO during ODS in a four step process. It started in the Guidance, Apportionment and Targeting (GAT) cell where the officers began by translating the JFACC's guidance into a coherent, coordinated plan— the MAAP [7, Part II,10]. This first step includes the analysis of intelligence and BDA to determine a set of prioritized targets that should be included in the MAAP given the JFACC's guidance [11, 12].

The second step produced the MAAP. The MAAP consisted of hand-written worksheets containing six kinds of information:

1. TOT,
2. Mission number,
3. The basic encyclopedia number (BEN—a standard reference to the Defense Intelligence Agency's automated installation file identifier),
4. Target code (A GAT specific code used to identify target categories),
5. Target description, and
6. Number and type aircraft conducting the attack.

Planners formed the MAAP by using information on munitions and aircraft availability. Planners matched aircraft, munitions, and targets from the prioritized target list to create specific strike packages. The strike packages were assigned TOTs, and appropriate support aircraft such as escorts or jamming aircraft were included in the MAAP worksheets. The information from step one and step two were combined to form the MAAP [7, Part II,10].

In Step three, planners performed detailed target development and weaponeering at the force level. The outputs of step three were target planning worksheets (TPW)[11, 13]. When completed, the TPWs contained all the information necessary to build the ATO [7, Part II, 15].

Once the TPWs were complete, they were passed to the ATO Division for completion of the fourth step, ATO production. The MAAP served as the starting point for the ABP. ATO division officers assigned communications channels, IFF codes, call signs, and tankers to aircraft. Planners included weaponeering data, munition assignments, and aim points, for strategic targets. Addition-

ally, planners performed complex coordination to ensure that strike packages were in the right place at the right time without wasting fuel or without being unnecessarily exposed to enemy threats.

In step four, planners also allocated support aircraft to strike packages—High Value Airborne Assets (HVAA) and Combat Air Patrol (CAP) aircraft. Approximate aircraft route planning was accomplished so the planners could determine suppression of enemy air defenses (SEAD) requirements for the strike packages. Planners also include HVAA locations in the ATO. Figure 5 illustrates the information and products of the four steps.

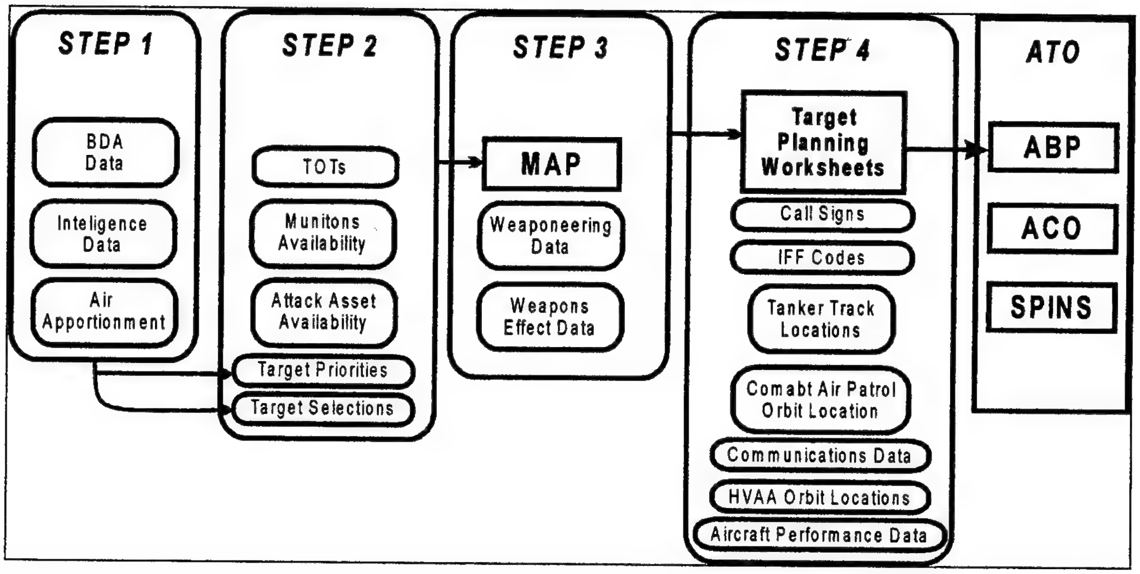

Figure 5. ATO Information Flow

2.3.2 Desert Storm Time-Line

The Desert Storm planning cycle started in the GAT cell around 0800 hours. The GAT's job was to translate the JFC's (General Schwarzkopf) and JFACC's (General Horner) guidance into a coherent, coordinated plan—the MAAP [7, Part II, 10]. The MAAP produced by the GAT was a coherent plan designed to produced a specific effect. It was well thought out; it was not an *ad hoc* matching of aircraft to targets [7, Part II, 192].

Along with the commanders's guidance, the GAT had to incorporate intelligence updates and BDA received overnight from various sources. Current intelligence and BDA information is critical in building an efficient and effective plan. The planners do not want to send packages into areas of high surface to air threats without appropriate suppression of enemy air defenses (SEAD) or retarget those targets previously destroyed.

The GAT worked on the MAAP from approximately 0800 to 1800. They turned over a draft of the MAAP to the night targeting cell (NTC) when they arrived around 1800. The NTC would massage the draft MAAP by weaponeering targets, building and coordinating packages, and performing the other necessary tasks to turn the conceptual plan into an executable plan. The NTC process was very informal with each weapons system expert checking the plan for glaring inconsistencies or errors as well as coordinating support assets needed to accomplish the missions. Any changes to the plan were coordinated with the other NTC officers. A 1900 hours Commander-in-Chief's meeting provided another source of changes that had to be incorporated into the plan by the NTC. By the end of the night, a completely coordinated attack plan was produced [7, Part II, 13-14].

The NTC planners placed all targeting and coordination information on the TPW. Each sortie that released a weapon had a TPW. The worksheet contained all targeting details as well as all the coordinated support such as force protection or SEAD. Completed TPWs provided all the information necessary to build the ATO [7, Part II,15].

By 0430 the NTC completed the TPWs and handed them over to the ATO Division. The ATO Division completed coordination with tankers, air space controllers, and units. Once coordination was complete, the tasking data was entered into CAFMS. The ATO was then transmitted at 1800 on Day 2. The orders effective period began at 0500 the next morning giving the units a maximum of 11 hours of planning, provided there were no delays in receiving the ATO. Figure 6 shows the ODS planning time-line.

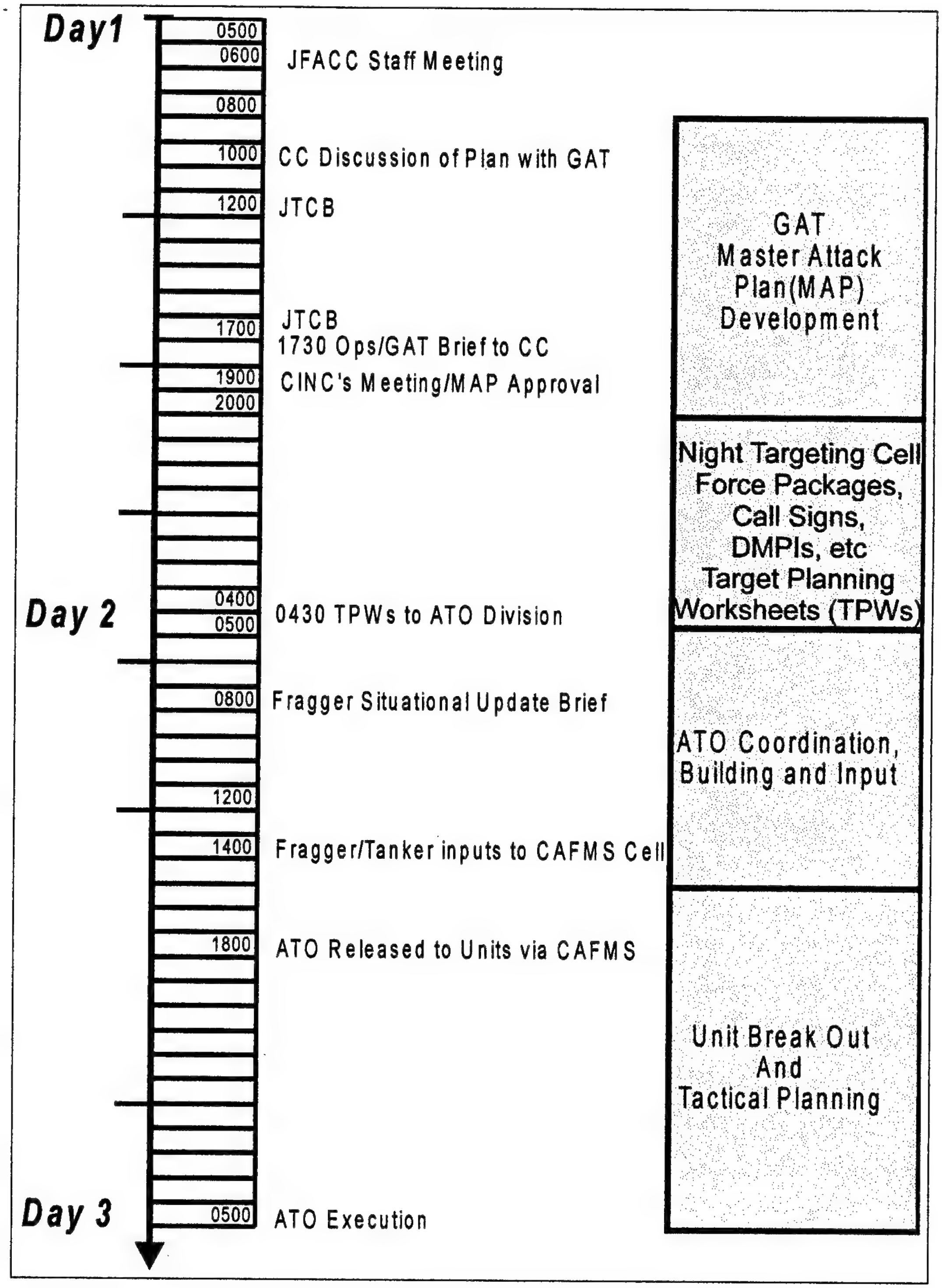

Figure 6. The Operation Desert Storm Planning Timeline

2.3.3 Desert Storm Decision Points

Most formal decisions in the planning cycle took place in the first 24 hours. First, the JFC supplied the initial apportionment and high-level targeting guidance to the GAT around 0800 hours. At 1200 and 1700 the Joint Targeting and Coordination Board (JTCB) met so command representatives could present their own prioritized target lists for the Kuwaiti Theater of Operations (KTO). The JTCB prioritized the requests and produced the Joint Integrated Prioritized Target List (JIPTL). The updated target list was passed to the GAT by 2000 hours to be incorporated in the current draft MAAP. The last formal decision point was 0800 of Day 2 when the JFC reviewed the ATO [11, 15-16]. If this was the last time changes could be introduced into the current plan, the process may have been less chaotic. However, GAT planners saw last minute changes as a way to get the maximum effectiveness out of the sorties flown and the number of changes caused significant problems.

2.3.4 Problem Areas

The GAT's primary objective was to maximize the use of the available sorties, and to hit the most important targets across all target categories everyday. This usually forced a large number of changes as weather and intelligence information was updated throughout the planning period. The GAT planners made changes to the ATO under the assumption that those changes would improve the overall effectiveness of the air campaign. During the 43 day air campaign of Desert Storm, planners averaged more than 500 changes per day. This contributed to the chaos and complexity of the war and taxed the CAFMS software to nearly exceeding its limits. The system in place was not responsive enough for the JFACC and the GAT commander, General Glosson. Therefore, they expected package commanders to exercise tactical initiative and find their own tankers or to make major in-flight adjustments to accomplish the mission [7, Part II,195-230]. This resulted from Glosson's belief that war is a problem in

"managing chaos. That doesn't mean you don't plan, that doesn't mean you don't try to make everything

as predictable as possible, but it's just not that way. There are other people that refer to this as the fog of war. You cannot let yourself get to the point where you are so predictable that everything is just like a cookbook. That's how you get people killed, that's how you lose." [7, 229]

Particularly affected by the number of changes were the air interdiction aircraft that primarily dropped precision guided munitions (PGM) such as the F-15E, F117, and F-111. The pilots of these aircraft believed the number and late timing of the changes resulted in reduced effectiveness, and increased vulnerability to threats and fratricide. Target changes and timing changes caused the most disruption. For example, a single target or timing change meant recoordinating and resynchronizing with the other strike and support sorties, as well as with the tankers. In addition, the changes affected crew rest and maintenance cycles. The last minute changes also created a demand for target descriptions and imagery that crowded out other activities in the mission planning cycle. The pilots of these units believed that six hours was the minimum planning time to effectively employ their weapon systems [7, Part II, 230-232].

Perhaps the biggest pitfall with the GAT attempting to maximize the use of current sorties was that most of the changes were based on uncertain information. The GAT officers planned and made comparisons among strike options despite uncertainty about future outcomes, and outcomes of strikes that had already taken place. The GAT planners created more uncertainty by making the last-minute changes to the current plan instead rolling the changes into the end of Day 3 planning. The more chaos the GAT planners created, the less quality information they had available for decision making [7, Part II, 212].

This all begs for some "miracle tool" to store and manipulate the necessary data in an effort to reduce the amount of chaos in planning an air campaign. The problem is not easy.

2.3.5 Possible areas of Improvement

The JFACC is charged with two conflicting goals: produce an ATO that is "flyable" and maximize the application of air power in support of the theater campaign objectives. A "flyable" ATO is produced through deliberate and coordinated planning. The second goal requires the flexibility to change the plan at the last minute to respond to incoming intelligence. The RAND Corporation has made several suggestions for improving the responsiveness of the planning cycle. They include:

- Do away with the current process and let the wings "do their own coordination."
- Shorten the planning cycle time.
- Change the structure of the process to allow only a limited number of changes to the plan at specific points in the process time-line.
- A combination of the second and third approaches. [11, 25]

2.3.5.1 Decentralized Planning

The first suggestion by the RAND Corporation appears to conflict with one of the basic tenets of airpower—centralized control and decentralized execution. However, their idea entails using a real-time collaborative planning environment that would give the operational wings near-instantaneous access to a central planning database. The operational wings would be given "mission-type orders" and then plan and coordinate their own tasking based on those orders. Some form of supervision would still be required to deconflict individual unit plans, thus serving as the centralized control. However, technology does not yet exist to produce such a system, and it is unlikely that such a system with the necessary bandwith could be developed given current budget constraints. Thus this is not a feasible course of action [11, 25-26].

2.3.5.2 Benefits of Shortening the ATO Planning Cycle

The RAND Corporation suggests a way to shorten the planning cycle to 24 hours. Such a compressed planning cycle offers several advantages. First, the attack force becomes more responsive. Targets nominated are struck the very next day instead of two days from the start of the planning.

In addition, only one planning process is carried out each day instead of the two parallel processes under the current system. This would make coordination within the AOC easier, and the shortened cycle would simplify the coordination with the 24 hour planning cycle used by the Navy aircraft carrier operations [11, 26].

In ODS, *ad hoc* processes were invented to inject target changes at any time within the planning cycle, but these changes frequently were disruptive and reduced the overall efficiency of the attack plan. By adhering to a more highly-structured planning process that allows changes at only specific prescheduled points during the process, potentially disruptive changes during the final stages of MAAP and ABP coordination would be rolled into the next day's planning cycle. This would allow the JFACC to pursue a more responsive attack strategy while preserving the benefits of a deliberate planning process [11, 27]. The key to these changes is reducing the planning cycle to 24 hours.

2.3.5.3 Shortening the ATO Planning Cycle

The RAND Corporation suggests that to shorten the ATO process, the time required to make key decisions must be compressed. The majority of the key decisions must be made near the beginning of the planning cycle. In addition, further automation of the process is necessary, as is dividing the planning subprocesses intelligently to reduce the time required to perform and coordinate them [11, 27].

CTAPS already automates much of the planning process such as ABP production and ATO compilation. It partially automates target development and weaponeering. The area that is still predominately manual is the MAAP production. Automating MAAP production could significantly speed up the planning process. It is believed that a 55 percent reduction in MAAP planning time can be accomplished with automation, reducing the MAAP planning time from eleven hours to five hours [11, 28]. A MAAP automation tool would go a long way in reducing the planning cycle time

to 24 hours. The JPT is a promising automation tool that includes a MAAP production capability based on an optimal weapons allocation model called Conventional Targeting and Effectiveness Model. JPT version .3 is currently in use at 12th Air Force, 8th Air Force and USAF Air to Ground Operations School [6, 15-17].

While the JPT shows promise, operational experience with the planning tool reveals the current output is difficult for planners to interpret. The single aircraft, armed with a specific weapon, assigned to a target from the TNL provides some insight to the problem, but the display is too difficult to transform into strike packages [12, 10]. Some of this problem is caused by the planners not understanding what the model output really represents. The assumptions of the model limit the decision space and in some situations may not produce an acceptable result. However, for what it is designed to do, CTEM within JPT performs very well. The key is understanding what assumptions the model is using. The question of whether it is an adequate MAAP planner or not has to be a qualified no. The output still needs expert analysis to identify and address the contradictions to all of the assumptions. Air Campaign planning is an extremely complex process and the current technology has not adequately automated the MAAP planning process.

Chapter 3 - MAAP Automation Analysis

To adequately use MAAP automation tools, the air campaign planner must understand what assumptions the model makes and how they affect the assignment of weapon systems to targets. The JFACC's planning team develops a strategy based on nominated targets. The JFACC prioritizes the targets to accomplish the objectives set forth by the JFC and the NCA. Servicing the TNL is a major function of the MAAP planning process. Each weapon system brings different limitations and strengths to the plan. However, the target list cannot be assigned sequentially beginning with target one. For the planner to maximize the efficiency of the air campaign, several factors are considered, including:

- JFACC guidance,
- Target priorities,
- Combat assets,
- Tactics,
- Weather,
- Enemy threats,
- Geography,
- Environmental conditions,
- Rules of Engagement, and
- Probability of damage.

Understanding how a model handles these considerations is critical for the planner to adequately use the model.

3.1 Conventional Targeting and Effectiveness Model Overview

CTEM is a mathematical model that optimizes goal achievement by selecting strategies made up from combinations of weapons, target, aircraft and SEAD; the strategies are selected based on the predicted probability of damage (PD) of the strategy. CTEM performs allocations for either side in a scenario. AEM Services Inc. developed the model in 1992 as a logical outgrowth of the Arsenal Exchange Model under a project sponsored by HQ USAF/XOOC. The model is very flexible and

has a diverse set of analyst controls [8, 4]. The user's manual defines 497 input variables. CTEM was specifically designed to address force analysis problems such as weapon system analysis, weapon employment policy support, force management analysis, and general weapon calculations.

CTEM is more like an optimization system than a single optimization model. It uses a pre-processor, DOMOD, to manipulate data for weapons effects calculations and threat levels. DOMOD performs a variety of functions including:

- build a defense grid,
- label each target as high, medium or low defended,
- map each target to a SABSEL target class using cat codes,
- shred out and count targets into target classes,
- build internal files to support CTEM aircraft packaging,
- extract PD data from SABSEL and prepare an input file for CTEM,
- expand target elements, and
- add targets onto the target list.

CTEM then takes the input and solves a series of linear programs to optimize goal achievement subject to the constraints set up by the analyst. Once CTEM makes weapon allocations, it uses a mixed integer program to perform "smart rounding" to integerize the solutions. Finally, CTEM uses a back-end heuristic for package building. The back-end heuristic takes the weapon/target/aircraft combinations and matches them to the geography of the AO. The heuristic matches aircraft to flights and flights to packages, and determines the TOT for each target. Each of these CTEM functions contains assumptions to simplify the problem, but the assumptions also impact the possible solutions considered and not considered in the model.

3.2 Assumptions and Limitations in Using CTEM

CTEM is the force analysis model used in the JPT. It is the tool used to automate MAAP building. Planners must keep in mind that CTEM is a mathematical tool. It optimizes based only on the mathematical goals specified by the user. If the consideration cannot be input into the model as a goal or constraint, it will not impact the solution. Even with current advancements in comput-

ing power, mathematical models have limits on the size of problem they can solve in a reasonable amount of time. Examining CTEM's processes reveals some of the limitations the user needs to be aware of when trying to build an air campaign. The processes can be broken down into DOMOD, which determines the PDs assigned to the chosen strategies, the LP calculations, and the packaging heuristic.

3.2.1 DOMOD

DOMOD is a preprocessor that disassembles SABSEL weapons-effects data to find the single shot probability of damage (SSPD) for a single weapon or load-out against a specific target. SABSEL is a weapons-effects model that computes expected kills per sortie for a particular aircraft, weapon, target, and delivery profile. The model uses JMEM weaponeering methodologies along with a separate model for dispenser weapons with independently guided submunitions like the Sensor Fuzed Weapon (BLU-108) [18, 64].

3.2.1.1 SABSEL

Computation of PDs in SABSEL requires an extensive database of weapons, aircraft, target and delivery parameters. The Weapons Effects Database (WEB) supplies this information as well as additional required information such as: target description, JMEM effectiveness index (EI) of the weapon against the target, aircraft delivery system accuracy, aircraft/weapon/target delivery profiles, and valid weapon load-outs for the aircraft [18, 64].

To determine the PD, SABSEL tries to maximize the PD subject to achieving at least the preset required damage expectancy (DE) against the target. It considers several strategies depending on the weapon configuration of the aircraft [18, 64].

For an aircraft delivering unguided weapons in a sequential stick, SABSEL assumes the pilot delivers all the weapons on a single pass, and concentrates on computing the optimum stick length

and release sequence. If an aircraft is loaded with PGMs, SABSEL searches through various delivery strategies to determine which one will yield the maximum PD. These strategies include:

- attacking multiple targets on one sortie,
- making multiple passes on a single target to achieve the required DE, and
- switching from point to area targeting for guided weapons to increase DE.

3.2.1.2 Disassembling SABSEL

As can be seen from the previous discussion, SABSEL is a very detailed and complicated model by itself. Each SABSEL yield represents a specific strategy combination from the parameters in the WEB database [18, 65]. However, CTEM develops its own strategies of weapon/target/aircraft combinations. These do not necessarily match up with the SABSEL strategies because CTEM generates many more strategies than SABSEL. Therefore, DOMOD disassembles the SABSEL data to determine the SSPD for a single guided weapon or load-out against a target [9].

DOMOD will try up to 23 different cases to determine what strategy SABSEL used to figure the underlying SSPD. The program then extracts the single weapon SSPD and recalculates the overall PD based on its own strategy. CTEM calculates a Compound Damage Expectancy (CDE) using

$$CDE = 1 - (1 - DE)^N \tag{1}$$

where:

$DE = PA \times PSSK$.
$PA \equiv$ probability of arrival.
$PSSK \equiv$ single shot kill probability or (SSPD).
$N \equiv$ number of weapons/sorties allocated (guided weapons$\Rightarrow$ $weapon$, unguided weapons$\Rightarrow$ $sorties$).

3.2.1.3 Problems with DOMOD

One of the weaknesses of this approach is that some information in SABSEL is not amenable to this sort of disassembling. For example, SABSEL uses JMEM linear-target methods to calculate the number of weapons required to close a runway. This method does not measure target damage, but

determines a number of cuts required to get the desired probability of closing the runway. SABSEL then computes the number of cuts per pass the aircraft and weapon configuration can produce. This allows the model to calculate a yield that can be used to determine the sorties required to close a runway. The SSPD is then calculated backwards from the number of cuts and passes:

$$SSPD = \frac{1}{Number\ Passes \times Number\ Cuts}. \tag{2}$$

CTEM would misinterpret this SSPD. It would compute a CDE based on the number of weapons (guided) or sorties (unguided) and the CDE would imply a probability of closing the runway. However, the reality is the strategy may have no chance of closing the runway because the strategy does not specify enough ordnance to make all the required cuts. On the other hand, when required PDs are relatively high, the number of weapons and sorties increase providing adequate numbers to make the required cuts and the end results match more closely. Once the required PD drives up the number of weapons and sorties to achieve the required cuts, the results are quite adequate. In this case SABSEL has changed to using *number of sorties* as the measure while CTEM is still using PD.

A similar problem occurs with unguided weapons. SABSEL only considers the area target single-pass strategy. In low-threat and medium-threat environments, aircraft such as the A-10 can carry weapons loads that allow multiple passes against point targets with free-fall or forward-firing unguided weapons. Depending on the type of target, the CTEM CDE could significantly underestimate the level of damage to the target for these scenarios.

These are a couple of scenarios the planner needs to be aware of when using CTEM to build a MAAP. The majority of the time DOMOD replicates SABSEL and produces an acceptable PD.

3.2.2 Linear Programs

The actual optimizing calculations take place in the linear program. It tries to maximize the values in its objective function by choosing strategies which contribute to goal achievement (Equa-

tion 1). Possible strategies can be limited by using constraints. In CTEM, these constraints can be arranged and solved in terms of priorities through the use of goal programming. For more information on linear programming refer to Wayne L. Winston's text, *Operations Research Applications and Algorithms* [17].

Examining the objective function, constraints and goal programming techniques used in CTEM reveals what considerations and values the model uses to determine the strategies selected. More importantly, it reveals what is not considered in the solution. This section also examines why assumptions are used in mathematical models to reduce the number of variables in the problem.

3.2.2.1 Objective Function

The CTEM objective function maximizes value by choosing strategies of aircraft/weapon/target combinations that best contribute to goal achievement. These are usually strategies that have high PDs or target values. When using goal programming techniques the target values are usually set to unity so that they do not impact the objective function. The PD value is based on the DOMOD calculation of SSPD and is modified by probability of arrival and SEAD information. The probability of penetration increases if SEAD is assigned to the strategy and thus a higher CDE results.

The probability of arrival is the probability an aircraft successfully employs the weapon against the target. The PA equation is

$$PA = RL \times PTP \times TDEFLEAK \times [PLS \times TSURV \times CCUBE] \tag{3}$$

where:

$RL \equiv$ weapon reliability of weapon type j.
$PTP \equiv$ a reliability degradation factor relating to the general probability of penetration of a carrier type i.
$TDEFLEAK \equiv$ single shot leakage of the defense against the weapons defined in TDEFWEP (these values represent the probability of penetration of specific weapons against the defined defense levels).
$PLS \equiv$ estimated pre-launch survivability for a specified base for a specified side.
$TSURV \equiv$ survivability of a specified target class on a specified side.
$CCUBE \equiv$ probability of successful command and control in passing the message to fire.

Most of these seven probabilities are set to one by analysts using CTEM. PA is used to model the idea that not every weapon that takes off gets expended against its target. Some weapons fail to perform as advertised and a weapons reliability number (RL) is included in the PA as well as a SEAD corrected probability of penetration (TDEFLEAK). Equation 1 shows that PA directly impacts the CDE value of a strategy.

Mathematically the objective function would look like

$$\sum_i \sum_j \sum_k \sum_s STRAT_{ijks} \times CDE_{ijks} \times V_k \tag{4}$$

where

$STRAT_{ijks} \equiv$ the number of strategies of aircraft type i, weapon type j, target type k, and strategy type s.
$CDE_{ijks} \equiv$ the compound damage expectancy of aircraft type i, weapon type j, target type k, and strategy type s.
$V_k \equiv$ target value of target type k (normally set to 1 when using the goal programming method).

Equations 1, 3 and 4 show that PDs and PA, which includes SEAD, are the dominant factors in what strategies the LP chooses. The choices are further shaped by the constraints the analyst places on the LP. This is where the real power of CTEM lies.

3.2.2.2 Constraints

The constraints restrict the number of aircraft, weapons, and targets available. Obviously, the planner would not want more aircraft allocated to the plan than are available. This would be infeasible and thus not a very useful plan. There are also special constraints or "hedges" as they are called in the CTEM manual, that provide a powerful capability to customize the model for a particular set of circumstances. The analyst can specify up to 120 hedges in CTEM to add auxiliary goals, side conditions, or extra requirements that must be met by the model's allocation while still trying to maximize the objective function. Analysts can apply hedges in the following general categories:

1. **value hedge**—specifies the average level of damage on a specified set of target classes by a specified set of aircraft and weapon types based on the target values. Example, Kill at least 1000 units of energy targets with stealth type aircraft.

2. **weapon hedge**—specifies the type and number of aircraft/weapon combinations that can be allocated to specified set of targets. Example, use less than 300 AGM-65D Maverick missiles against phase 1 targets.

3. **target hedge**— constrains the total number of targets attacked by a specified set of aircraft and weapons. Example, kill 70% of artillery with any valid aircraft/weapon combination.

4. **CDEMIN hedge**—requires a specific level of damage to each target in the specified set of target classes. Example, all bridges must have a PD greater then 0.9.

5. **attrition hedge**—controls the amount of attrition experienced in the allocation. It can be used to limit the attrition in accomplishing a set of goals or limit the attrition for all or a part of the sorties.

6. **acceptance hedge**—requires all strategies for specified aircraft, weapon, target combinations to satisfy a set of criterion. The criterion deal with the amount of damage obtained in the strategy, the number of weapons involved or the presence of certain weapon types in the strategy [8, 67-68].

For example, during Operation Desert Storm it became necessary to target some bunkers with two PGMs to get the desired penetration and subsequent weapons effects. The acceptance hedge would limit the strategies for this target class to only the required two PGMs.

What this really means to the planner is that multiple objectives and restrictions can be placed on the model to better conform to the operational environment of the AO. Aircraft types can be

limited to certain types of targets and levels of desired damage specified to appease political or operational requirements. CTEM contains significant flexibility with its use of hedges. However, it is not an easy option for the casual user to employ. Problems can arise from conflicting or overly restrictive constraints. The more constraints placed on the problem, the smaller the solution space available to the model. The key for the planner is translating operational requirements into hedges. If the operational requirement can be defined as a function of the CTEM variable, then the hedge can probably handle it. If it is a subjective, qualitative decision, then the man-in-the-loop needs to make the decision.

CTEM also has control variables that can be used to perform specific functions similar to hedges. These include:

- ALLOW—Specifies weapons which are allowed to attack specific target classes. This limits the weapons available to strike the specified targets. Example, ALLOW(highdef, stealth) would limit the class of targets designated as highly defend to attack by only Stealth type weapons.
- DISALLOW–Specifies weapons which are not allowed to attack specific target classes. Example DISALLOW (sams,A-10) would prevent A-10s from striking sam class targets.
- PROHIBIT— Prevents specified weapons and/or aircraft from attacking specified targets. Example, PROHIBIT(*)=Airfields+B-52+PGM would prevent -52s from striking airfields with PGMs.
- RESTRICT— Restricts specified weapon and/or aircraft to attacking specific targets. Example, RESTRICT(*)= armor+A-10+AGM-65 would restrict the use of A-10s with AGM-65s to armor type targets only.

These input variables let the analyst "tweak" the allocation process. If an aircraft/weapon combination was known to perform poorly for other than PD reasons against a specific type of target, the analyst could restrict the combination from consideration. If the poor performance was due to PD or penetration capability, it would be unlikely that CTEM would choose it anyway.

3.2.2.3 Prioritizing Goals

Air campaign planners not only establish goals for the campaign, but also prioritize these goals. CTEM allows this to happen in two ways. In the first way, the analyst sets the priority of each goal.

CTEM then solves a sequence of LPs attempting to satisfy the highest level of goals. If the goals are met, CTEM treats them as equality constraints and moves to the next level of goals. While solving subsequent goals, CTEM allows the allocations of previous goals to be changed as long as the value achieved is not degraded. This technique assures that as many as possible of the number of high priority goals are satisfied. The user is not limited to a single goal at a priority level; the user may designate multiple goals at any level. The benefit of this approach is that it more closely resembles the strategy-to-task approach of air campaign planning and eases the translation of campaign goals into the model.

If CTEM is unable to achieve a goal, its code forces the LP to maintain accomplishment of the highest level achievable and it moves on to the next priority level. If there are multiple goals at the same level that CTEM cannot satisfy, it uses standard goal programming techniques to determine the level to achieve in each goal.

One problem with this sequential priority approach is that a higher priority goal can overwhelm a lower priority goal. For example, completely achieving the highest priority goal may cause a lower priority goal to be achieved at a significantly reduced level. However, if the highest priority goal was reduced to 90% achievement, the lower priority goal could be achieved at a significantly increased level. It may be more beneficial to embrace the second strategy of a more balanced goal achievement. CTEM permits a way for the goals to be solved simultaneously through the use of user defined penalties.

CTEM allows users to set their own penalties for not achieving goals. In this way, users can implement goal constraints in a non-preemptive fashion. The objective function (Equation 4) would include the penalty and look something like

$$\sum_i \sum_j \sum_k \sum_s STRAT_{ijks} \times CDE \times V_k - \sum_g M_g \times DIF \qquad (5)$$

where

$M_g \equiv$ penalty value for goal g.
$DIF \equiv$ positive difference between what the goal has achieved and the value desired by the user.

By adjusting the value of M_g users can penalize the objective function for not achieving a specific goal. The value of M_g can be adjusted to favor one goal over another. If the user does not input a value for the M_gs CTEM defaults to an average goal satisfaction by normalizing the penalty for each goal. The default equation for M_g is

$$M_g = 2 \times \frac{\sum_k V_k}{V_g} \tag{6}$$

where V_g is the desired value of goal g (this is the right hand side of the constraint). CTEM multiplies the value by 2 to ensure the penalties are large enough to impact the value of the objective function. Using this approach, CTEM simultaneously solves the hedges to maximize the average achievement of all goals.

3.2.2.4 Curse of Dimensionality

CTEM must make a plethora of decisions while trying to maximize the PD of its allocation. By allocating weapons to targets, CTEM generates a large number of strategies and CTEM allows the target set to be categorized by up to 3500 classes. A simple example demonstrates how the problem can quickly get out of hand. Assume 3500 targets in a target set broken into 1000 classes. Assuming 20 different types of aircraft, 100 types of threats, 100 combinations of weapon types and 100 types of SEAD decisions, the number of options required by CTEM would be

$$3500 \times 1000 \times 20 \times 100 \times 100 \times 100 = 70,000,000,000,000.$$

Even if the program could consider 10000 options per second it would still take over 221 days to complete the problem. As the number of variables increase, the problem becomes impossible to solve in a reasonable amount of time. It is this "curse of dimensionality" that makes trying to model the air campaign planning process so difficult. Analysts must find ways to reduce the number of

variables so the problem can be solved in a reasonable amount of time. The method used in CTEM is aggregation, and the aggregation of data limits the detail and reduces the fidelity of the model.

3.2.3 Aggregation

Aggregation occurs in several areas in CTEM. The aggregation affects how aircraft and weapon combinations are allocated to targets. An examination of weather and SEAD aggregation can reveal how they effect target allocations.

3.2.3.1 Weather Aggregation

CTEM can handle weather in one of two ways: *fixed* weather or a *weighted* weather. In the fixed weather approach, the user predetermines which SABSEL weather state is applicable and DOMOD picks the best delivery for each aircraft/weapon/target combination based on PD and weather state. Put more directly, DOMOD chooses the delivery with the best SSPD for all deliveries possible and the predetermined weather state.

The fixed weather approach has good points and bad points. The good points are that with today's modern technology, planners should have a good prediction of the weather available, and if the weather is fairly uniform over the AO, a relatively good prediction of PD can be made. However, the weather is rarely uniform over an entire AO. This can cause a poor representation of the PDs if the weather is highly variable. Then there is that inherent ability of the weather to provide surprises even with modern weather prediction technology of today.

The second method CTEM uses for modeling weather is a weighted weather approach. The analyst inputs the percentages for each of the six SABSEL weather states. DOMOD then performs a weighted average of the maximum SSPDs over all weather states. This approach attempts to reduce the variability between the predicted SSPD and the actual SSPD due to weather. The averaged SSPD values should be closer overall to all the actual SSPDs if the proportions are input correctly.

However, if the predictions can be wrong with the fixed weather approach, the weather can also surprise the planners in this weighted approach resulting in a significant mismatch of SSPDs. Another problem with this approach is that not all target classes are evenly distributed among all the predicted weather states. Particular classes of targets can be poorly represented, but if each target was modeled separately the model would grow significantly.

3.2.3.2 SEAD Aggregation

SEAD is used to improve the PA (Equation3). Each SEAD weapon is assigned a SEADCAP (the probability of successfully suppressing a defense) and the improved penetration is figured by

$$IMPTDEFLEAK = (1 - TDEFLEAK) \times SEADCAP + TDEFLEAK \tag{7}$$

where:

$IMPTDEFLEAK \equiv$ the improved penetration of a platform due to SEAD.
$TDEFLEAK \equiv$ single shot leakage of the defense against the weapons defined in TDEFWEP (these values represent the probability of penetration of specific weapons against the defined defense levels).
$SEADCAP \equiv$ the capability of the SEAD asset to successfully suppress a defense.

The threat level classifications of each target are determined by a preprocessor called HML (High, Medium and Low) which is actually part of the DOMOD program. The program overlays a grid over the AO and classifies each grid as high, medium or low depending on various SEAD effectiveness estimates and threat locations. Each target location is correlated with the threat grid to determine its threat classification. HML is not a route optimizer, but a rough compact way to quickly categorize the threat levels associated with the targets so CTEM can have some guidance on how to allocate SEAD and compute attrition. The limitations of HML include having only assessments for the F-16 at a penetration altitude of 20.000 feet. Also any target in a grid picks up the threat level of the grid no matter where the location of threat is in relation to the target or the terrain that might shield the target from the threat. This obviously limits the fidelity of the SEAD model significantly.

Another assumption of CTEM concerning SEAD is that SEAD is never lethal; it is only suppressive. The users need to specifically target defenses if they want to kill them.

3.2.3.3 Targeting Aggregation

Another area where CTEM aggregates is in the targeting process. CTEM makes a distinction between the allocation of weapons to targets and the application of weapons to targets—the latter being more specific. Allocation involves assigning weapons by type to targets by type. To CTEM a target of the same type is identical and the process of assigning a weapon to it is identical. The reality is that location, environment, threat and a host of other factors make each target a unique targeting problem. CTEM sees only multiple targets of the same type and assigns weapons accordingly. For example, the JFACC may have 12 bridges he wants serviced. CTEM would look at those 12 bridges as being identical and might assign 2 GBU-10s against each bridge [8, 16]. In reality, the environment around one or more of the bridges may make the use of laser guided bombs (LGBs) less than optimal.

The second level of targeting is the application of weapons to targets. In CTEM, application involves determining which specific 12 bombs from which aircraft, launched from which base will strike each of the 12 specific bridges. Application involves specifying latitude and longitude information for each attack as well as the actual TOT. Finally, it will involve any packaging desired by the planners.

3.2.4 Packaging

CTEM accomplishes packaging with a back-end heuristic. It is possible to combine the packaging into the LP, but the calculation times become prohibitive with the inclusion of more variables. Therefore, CTEM separates the package building from the weapon allocations. It uses input vari-

ables of dispersion, speed, and range to package aircraft. CTEM also needs to know where the aircraft are based (latitude and longitude) to complete the packaging assignment.

When CTEM allocates weapons to targets in the LP, it ignores the range and weapon/aircraft dispersion constraints. It allocates weapons to targets based on weapon/aircraft availability and maximizing the goal achievement. The heuristic works down the prioritized target list accomplishing the following sequence of events to build the strike packages:

1. CTEM assigns the specified weapons for each target to aircraft sorties at a base that has the appropriate aircraft/weapon combination.

2. the program attempts to build flights from allocated sorties of the same type aircraft at the same base by using the flight dispersion factor. The flight dispersion factor is the user specified maximum distance between targets before aircraft from the same flight are not allowed to strike them. The user also specifies a flight size which is the number of aircraft CTEM attempts to put in the flight. If CTEM is unable to build a flight of the specified size, it will divide the flight size by two until it can satisfy the requirement. Flights must be of the same type of aircraft.

3. CTEM builds packages from flights. Again the user specifies a package dispersion distance that keeps the flights in the package within a geographic area. Within packages, aircraft may be different. CTEM allows up to 30 flights in a package.

4. CTEM reconciles the assignments into "goes" based on input sortie rates and determines the TOTs for the packages.

The back-end package builder of CTEM does not optimize the package assignment. It looks for an acceptable answer given the user dispersion inputs and the allocation from the LP. Better selections based on operational considerations may be available. The heuristic's primary test is

whether or not the wingman or flight meets the flight or package dispersion criteria respectively. It is a geographical based approach to package building.

This has some good points, but examines a limited solution space. The good points to this approach are that it provides a feasible solution and puts packages in the same geographical area so they can share support assets such as SEAD, tankers, and force protection more. Another advantage of the heuristic is that it is solved relatively quickly.

However, several drawbacks and shortcomings emanate from this heuristic approach. First, the back-end does not use 5-10% of the sorties allocated in the LP [9]. The heuristic is unable to resolve all the timing and geographic scheduling problems. Some targets cannot meet the input flight and package dispersions and flight size criteria. The sorties lost are the ones where the targets are the most difficult to package. These could be high priority targets.

The back-end really does not address any operational considerations in package building. For example, assume a package included 18 F-16s. It is operationally sound to task all these F-16s from the same squadron, or at least from the same base so as to improve the strike coordination. CTEM does not consider the location of the aircraft except to ensure all wingmen of the same flight are from the same base. The 18 F-16s assigned to the package could come from several bases. Although this is a workable solution, efficiency of the strike would improve if all the F-16s were located where common mass planning could take place.

Another operational shortcoming of the back-end is that it does not consider the sequence of the strikes. It has no way of making sure targets that must be hit first, such as threats, are actually hit first. Again the user must adjust TOTs to provide a successful sequence for the strike. The final output from the model is not a usable MAAP as planners must still manipulate the output to have a functional plan.

3.2.5 Summary

CTEM is a fairly complex model that maximizes goal achievement via a linear program and probabilities of damage. It obtains the PDs from a preprocessor called DOMOD which disassembles data from SABSEL. The LP uses aggregation to limit the number of variables in the problem and therefore make it solvable in a reasonable amount time. The PDs in the LP are adjusted for the use of SEAD and weighted weather states. The model has the ability to model strategy-to-task objectives through the use of goal programming techniques. Finally the model uses a back-end heuristic to generate strike packages based on the geographical location of the prioritized targets.

Although a highly capable model, CTEM's aggregation and assumptions limit the fidelity of the model. Different uses of the model require different levels of fidelity. For good MAAP building more usable detail needs to be available. However, for higher level force analysis, CTEM is quite adequate.

CTEM's key criterion is probability of damage. However, other criteria such as desired target damage at a specified time or fuel and/or range may be appropriate. For smaller conflicts, it may be better to optimize for tactics or doctrine. Some of this may be accomplished through the intelligent use of hedges.

CTEM is a capable, complex model requiring extensive input data. It is not designed for the temporary weapons expert assigned to the AOC for a two week stint in the planning cell. It will be a mystery to most of those with the operational expertise and they will not be able to really exploit its capabilities.

3.3 Further Assumptions of CTEM in JPT

CTEM is only one aspect of JPT. It was designed as the primary MAAP building tool. When CTEM was included in the JPT, an attempt was made to simplify the inputs for the model by preset-

ting several of the input variables. The JPT user interface does not provide access to all the capability of CTEM. It limits the number of input variables that the user must set. However, users familiar with CTEM's flat data files can manipulate them to access more of CTEM's power. The limited inputs reduce the flexibility of the model even further and the user needs to be aware of these limits. This section discusses several of the limits on CTEM in JPT.

3.3.1 DOMOD Limitations

CTEM uses PDs as the primary source for determining if one set of allocations is better than another. The PDs used in CTEM to calculate the CDE of the allocation are determined by the disassembling of the SABSEL data by DOMOD. Currently CTEM recognizes 23 different cases of PD calculations that it must examine in determining how SABSEL calculated the PD for its chosen configuration. However, the SABSEL data in CTEM is several years old and only recognizes 12 cases of PD calculations[9]. This leads to poor PDs for the LP and consequently introduces error into the solution. Over time these errors can become pronounced if multi-stage campaigns are analyzed. Planners need to be vigilante in examining the allocations to make sure they pass the "common sense" test.

Another problem with the SABSEL data base is that it references targets that are facilities rather than desired mean points-of-impact (DMPI)[9]. This aggregates target descriptions at a level above DMPIs and is not suitable for detailed weaponeering required in a daily MAAP. This is another area where aggregation limits the fidelity of the model.

The user can set flags in DOMOD through the variable SHREDNAME. The SHREDNAME is a series of letters which tell DOMOD how to group targets in the ACPT file by target classes and how to name them. SHREDNAMEs can be defined with the following letter types:

- d ≡ defense level,
- m ≡ mission type,
- p ≡ phase,

- r ≡ range,
- s ≡ SABSEL target name,
- t ≡ task,
- c ≡ collateral flag (target is associated with collateral damage), and
- n ≡ sequential number used to create unique target names.

An example of a SHREDNAME would be *ssssssdmmmr.* DOMOD would group targets according to four criteria: the first six letters of the SABSEL target name, defense level, mission as specified in the mission field of the ACPT file, and range. In JPT the SHREDNAME is fixed. The user cannot tailor the SHREDNAME to the situation.

Finally, JPT is unable to screen the delivery profiles used by SABSEL. In JPT, CTEM uses the delivery profile that provides the highest PD. However, this profile may bear no resemblance to the actual profile required by the tactical situation. JPT adds more uncertainty into the PDs than already exist in the old SABSEL data. How much this impacts the solution is unknown. Weapon system experts need to use their expertise to make sure the solution is tactically sound.

3.3.2 LP Limitations

In JPT, CTEM has several of its input variables predetermined and these assumptions impact the type of solution the model produces. One such input variable allows each aircraft to strike only one target. In the past, this would have been a reasonable assumption for air interdiction (AI) targeting. However, aircraft like the A-10 can strike multiple targets on each sortie particularly in the close air support (CAS) role. One of the A-10's popular AI missions has been the kill-box mission where the aircraft patrols a geographic area striking any and all targets in the area until all ordnance is expended. The presence of PGMs also has transformed the AI mission. Most fighters in USAF inventory today can carry multiple PGMs which allows them to strike multiple targets on a single sortie. CTEM in JPT does not accurately capture these missions.

The JPT interface to CTEM allows only one set of goals even though CTEM supports many goals. Also, the hedging capability of CTEM in JPT is very limited as weapons hedges are not permitted. The hedging capability is one of CTEM's most powerful features. Having the ability to add constraints to the LP allows the user to adjust to some operational restrictions.

CTEM in JPT has three standard sink constraints that minimize the number of weapons, aircraft, and SEAD weapons used. However, this is not always the best allocation for the tactics necessary to successfully strike a target set. There are situations where more aircraft in a target area are better since defenses become overwhelmed and the survivability of all aircraft can increase significantly. An example would be the Joint Air Attack Team (JAAT) where A-10s and attack helicopters work jointly against a target area. Tactics validation tests in the early 1980's have shown that increasing the number of aircraft through a JAAT increases target destruction by 40% while reducing losses by 50%. The tactical advantage of a four ship over a two ship by having more firepower and mutual support available in the target area also demonstrates that minimum numbers of aircraft are not always the best answer. Increased survivability is inherent in increased numbers of aircraft in a target area. CTEM does not take this into account and through the minimization sinks, tries to prevent it. Sometimes it is better to cover more targets at once which the sinks allow, but at other times minimizing losses may be one of the objectives and mass is valid tactic for minimizing losses.

The JPT model treats all weapons the same. CTEM in JPT tries to minimize weapons, no weapons hedges are allowed, and the allocation of weapons to targets are based upon the PD the weapons inflict on a target. Operational or tactical reasons for choosing one weapon over another are not considered by the model. It only cares that the PD is the maximum it can achieve with the remaining weapon/aircraft combinations. A good example of an operational weapon consideration is the choice of using cluster munitions. If the Army is going to be rolling over the area soon, they may not want cluster weapons used on targets in front of them due to high dud rates of some cluster

munitions. The JPT model would not care what type of weapon was used as long as the PD was the highest achievable from the remaining weapons and aircraft. The man-in-the-loop would easily replace the cluster weapons with a suitable alternate even if it meant accepting a lower PD or using more weapons of a different type.

3.3.3 SEAD in JPT

The SEAD details are fixed in JPT except for the number of assets available for SEAD. The SEAD rate which is the number of targets made vulnerable by suppression is fixed, as well as the SEAD capability. SEAD capability is the probability that a SEAD asset successfully suppresses a defense. These are the numbers that are used to calculate how much the probability of penetration is increased by the use of the SEAD asset. While the numbers in JPT are reasonable numbers that have provided good historical results in the past. They are not flexible and the user needs to be aware of unique situations where the fixed numbers might be misrepresented.

Perhaps the biggest limitation to SEAD in JPT is that it is highly aggregated. CTEM in JPT classifies the aircraft and defenses as shown in Figure 7. Each one of the penetrator and defense type

Penetrator Type	Defense Type		
	High	Medium	Low
Stealth Medium Penetrator No Penetrator Stand-off Weapons	*Probabilities of Penetration*		

Figure 7. SEAD Classifications in CTEM

combinations in Figure 7 may have SEAD assigned to improve the penetration probability. SEAD can consist of seven weapon or jamming configurations for a total of 84 SEAD options. However in JPT, SEAD is modeled as on or off. The penetrator type/ threat type matrix (Figure 7) consists of all zeros and ones. If the penetrator type/threat type combination has a zero then the allocation is not allowed without SEAD. If the combination contains a one, then the allocation is allowed and SEAD is not assigned to that mission.

CTEM allows the user to set the definitions of high, medium or low threat. However in JPT, Checkmate's commonly used values are set as defaults:

- High threat—attrition rates greater than 1% with lethal SEAD and jamming.
- Medium threat—attrition rates less than 1% with lethal SEAD and jamming.
- Low threat—attrition rates less than 1% with no SEAD.

The SEAD aggregation reduces the level of detail in the problem significantly. Each aircraft is assigned one of three penetration categories and each threat is assigned on of three defense capabilities. Besides the weapons configurations and thus the PDs available for individual aircraft, this is the main measurement CTEM considers in whether the aircraft will arrive at the target.

Pilots think about the specific capabilities of each aircraft and how those can be matched against a threat's specific weaknesses to determine subjectively the probability of penetration. Tactics play an important role in the aircraft arriving at a target. What might be considered a medium threat defense for one type of aircraft my be a low threat defense for another. CTEM does not approach the problem in this way. In CTEM a defense is always the same defense category once it is assigned. For example, a F-16 might be considered a medium penetrator. The target it is allocated against is defended by an SA-8 which is categorized as a medium defense. CTEM would assign a specific probability for the medium penetrator/medium defense combination with no SEAD. However, the F-16 may be able to limit its exposure to the SA-8 by overflight or minimizing its time in the lethal envelope of the SA-8. The effect of these tactics is to increase the probability of penetration of the

F-16 against the assigned target. CTEM might try to allocate SEAD in a situation where none is needed or produce a significantly lower PD than is justified.

Limiting the aircraft and threats to three categories, diverges from the way pilots are trained to think when they approach the problem. They are trained to take advantage of their strengths and pit them against the enemy's weaknesses. CTEM within JPT tends to level the playing field and take away the areas where a particular weapon system may have a distinct advantage against a particular threat. The real question here is "does it matter?" The answer is "it depends!" For every situation where it doesn't matter, there is a situation where it does. The weapon system experts need to be aware of these assumptions and make judgements for each scenario based on their expert experience.

Finally, the SEAD methodology allocates SEAD when it appears SEAD will help. However, it does not make the operational decision, based on tactics or doctrine, of when to use medium penetrators and SEAD or use stealth technology. However, the model does make choices about which type of penetrator causes the highest overall goal achievement.

3.3.4 Other Considerations in JPT

JPT limits the number of range bins to two, long or short range. CTEM has the capability to capture three ranges, long, medium and short range. The three range bins capture the real capability of combat aircraft better than the use of two ranges. This is another way the fidelity of the model has been reduced through aggregation.

JPT does provide an interface to some of CTEM's variables such as PROHIBIT and RESTRICT (section 3.2.2.2). These give the users some control over aircraft/weapon/target combinations.

CTEM also provides access to the RL (reliability, section 3.2.2.1) variable of CTEM. It is one of the seven probabilities used by CTEM to determine the probability of arrival (PA). This allows

a direct correction to the PA. Planners need to aware that RL was originally designed for weapons reliability numbers, and probability of penetration figures are already included in the PA through the calculation of the TDEFLEAK variable.

Inputs in the RL field in JPT have a direct impact on the PA. The users need to know how these variables are set before they decide to modify them further. JPT does not provide this information and only by examining the flat data files could the user know what the preset values are. When using {0,1} SEAD (section 3.3.3) and with the other variables set to one, the RL value then becomes the planners subjective assessment for the probability of arrival of the specified weapon to the matched target protected by the associated threats.

3.4 Summary

The MAAP automation tool within JPT is the CTEM. The model uses a preprocessor to determine PDs based on an accepted PD model, SABSEL. It then solves a series of linear programs that maximize PD and satisfy goals or objectives as set by the user while allocating weapons to target. CTEM then uses a "smart rounding" technique to integerize the appropriate variables. The back-end of CTEM then performs a more specific assignment of weapons, aircraft and targets, and groups them geographically into strike packages using a heuristic.

An examination of these pieces of CTEM show several assumptions that are made to simplify and make the problem solvable in a reasonable amount of time. The planner needs to be aware of these assumptions because they impact the type and quality of the solution presented by CTEM. The user needs to know when the military situation does not neatly fit these assumptions and the solution might not be adequate.

CTEM is a very powerful model that gives the user many ways to mold the data to fit the given situation. However, several areas require aggregation to make the problem solvable. JPT tries to

limit the complexity of the model by presetting many variables, but this also reduces the fidelity of the model further. The analyst and the weapon system expert need to jointly determine when the models fidelity adversely affects the solution. A long range macro look at a campaign does not require the same level of fidelity as day to day MAAP building. The current version of JPT is probably not adequate for most daily MAAP building. It does not contain enough fidelity and it limits the capabilities of CTEM too much.

Chapter 4 - The Future of MAAP Automation

The previous sections illustrated several limitations with automated MAAP building. CTEM provides a good tool to aid in MAAP building, but the weapon systems experts still need to examine and correct the solution when the assumptions do not match the military situation. If input data needs to be corrected, the entire run of the model must be reaccomplished and this may be time prohibitive. Another problem is that minor changes in the input can result in a completely different allocation. A solution suggested by a Brown University White Paper on Re-Engineering CTEM includes providing the experts ample opportunity for modifying the data and overriding automated choices at various stages of the decision-making process. The software should be able to provide a completely autonomous solution, or function as a sophisticated decision support tool for the manipulation of candidate solutions [5, 1]. This section discusses the case for collaborative planning and reviews a new collaborative planning tool for CTEM called ADVISE.

4.1 The Case for Collaborative Planning

The fundamental idea behind collaborative planning is that it is easier to evaluate and modify a plan than create an original one. Therefore, let an automated system like CTEM find a reasonable starting point. Then the user can edit the plan with the support of graphical decision making aids. The scenario would go like this:

- The user specifies the initial inputs.
- The user runs the model to get its "optimal" solution.
- The solution is displayed to the user in a graphical format, showing the objectives, the degree to which they are satisfied, constraints, whether or not they are violated, etc.
- The user edits the solution and makes the model dynamically re-evaluate the edited solution updating the graphical displays. The user may decide to modify objectives or constraints as well.
- The user edits until satisfied with the solution and the problem is solved. [5, 17]

Allowing experts to collaborate in the decision process provides a way to address problems that are not explicitly modeled. In the dynamic environment of air campaign planning, this situation is

likely to be the more prevalent. Political and sociological factors as well as tactics can be difficult to model because of the amount of "art" involved. Also, collaborative planning appeals to decision makers because ultimately some individual or agency is held responsible for the decision. Therefore, the decision maker wants some grounds for believing the solution is appropriate if not optimal[5, 5].

Collaborative planning takes the emphasis for solving this type of problem away from the "black box" of mathematical programming by improving the user's involvement in and understanding of the decision making process[5, 17]. In this way weapon systems experts are involved in the total process and validate the solution as it is solved. Collaborative planning allows the weaknesses of the mathematical models to be overcome through the analysis of intuitive graphical interfaces by experts in the field.

The experts are likely to be more accepting of a process they can understand and adapt. By using the system and seeing how it reacts to their changes, the weapon systems experts become more familiar with the tool and learn how to apply it better in the dynamic environment of battle management. The tool also provides a sensitivity analysis capability. The users gain confidence in the solution by trying to improve upon it; if the experts cannot significantly improve the solution, then they gain some measure of confidence in the solution.

Collaborative planning may appear to be more regressive than complete automation, but most pilots will not use a system they do not fully understand. They prefer to have some capability to mold the solution to their ideas and concepts of how the campaign should progress. They have an intuitive and artful understanding of the problem from years of experience in employing their weapon systems. The nuances of each weapon system cannot be captured by a mathematical model and still produce a solution in a reasonable amount of time. Collaborative planning gives the experts the capability to adjust the solution to reflect the capabilities the model does not explicitly capture.

4.2 ADVISE

AEM Services Inc. has produced a collaborative planning tool for CTEM called ADVISE. It takes a slightly different approach than the one described in section 4.1. ADVISE allows the user to specify aircraft and weapon combinations for selected targets first and then solves the problem using CTEM to determine the strategies for the remaining targets. ADVISE uses a Visual Basic graphical interface to display and manipulate the CTEM data files as necessary to accomplish the planners preferences. The main screen (Figure 8) provides access to several key pieces of input data and provides access at two levels—one for the less-experienced user, and an advanced control for the more experienced user. ADVISE's version of collaborative planning is demonstrated by an

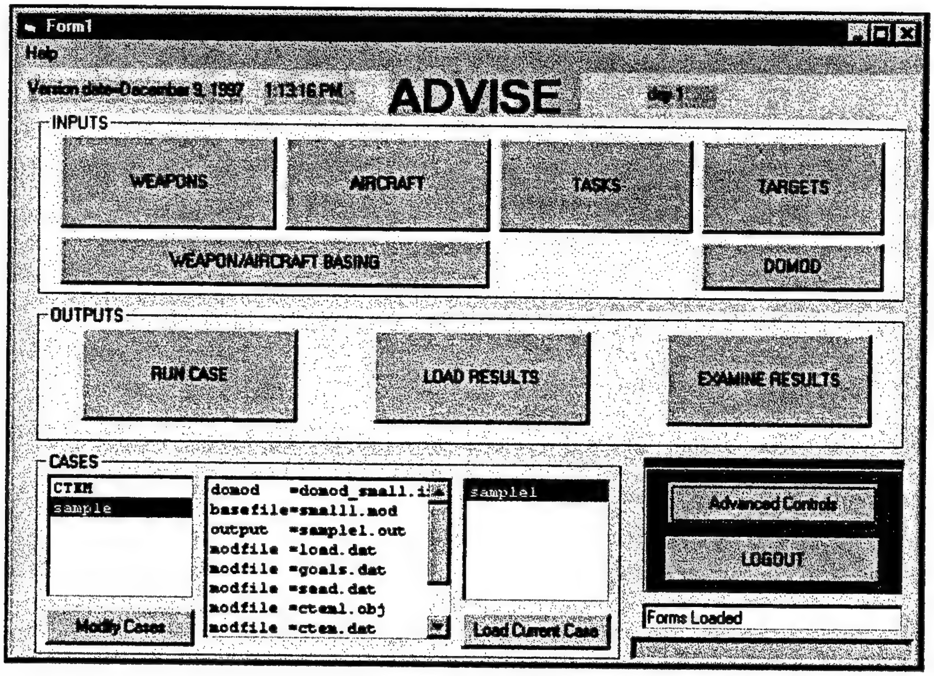

Figure 8. ADVISE Main Window

examination of its graphical interfaces. The version examined by this author was a pre-production version and several changes have been made to the current software. However, the idea of collaborative planning can be adequately demonstrated with the pre-production version.

4.2.1 Targets and Tasks

The real power of ADVISE resides in the *Target* interface. The target interface permits the user to specify aircraft, weapon and target combinations. These specifications then become binding constraints in the LP and CTEM solves the problem allocating strategies to the remaining targets. The interface displays a list of targets and when the user selects the target (using the pointing device) a secondary window displays the aircraft and weapon combinations available to strike the target as well as the PD expected and required (Figure 9). The users can allocate as many strategies

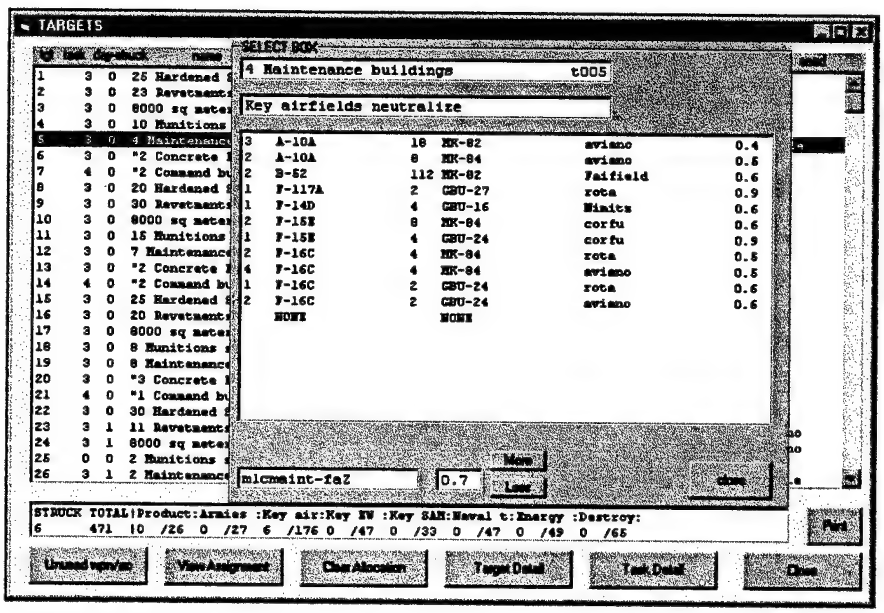

Figure 9. Target Strike Options Interface

as they like. The idea is to let the experts specify the type of strike on targets that require unique considerations not explicitly handled by the mathematical program. The number of targets specified can range from one to all of them. Once the users are satisfied with the strategies specified, CTEM is used to fill in the remaining allocations and determine which sorties require SEAD. Figure 10 shows a partially specified target list before CTEM finishes the allocation, and Figure 11 displays the CTEM completed allocation and assignment. A complete plan is contained in the appendix.

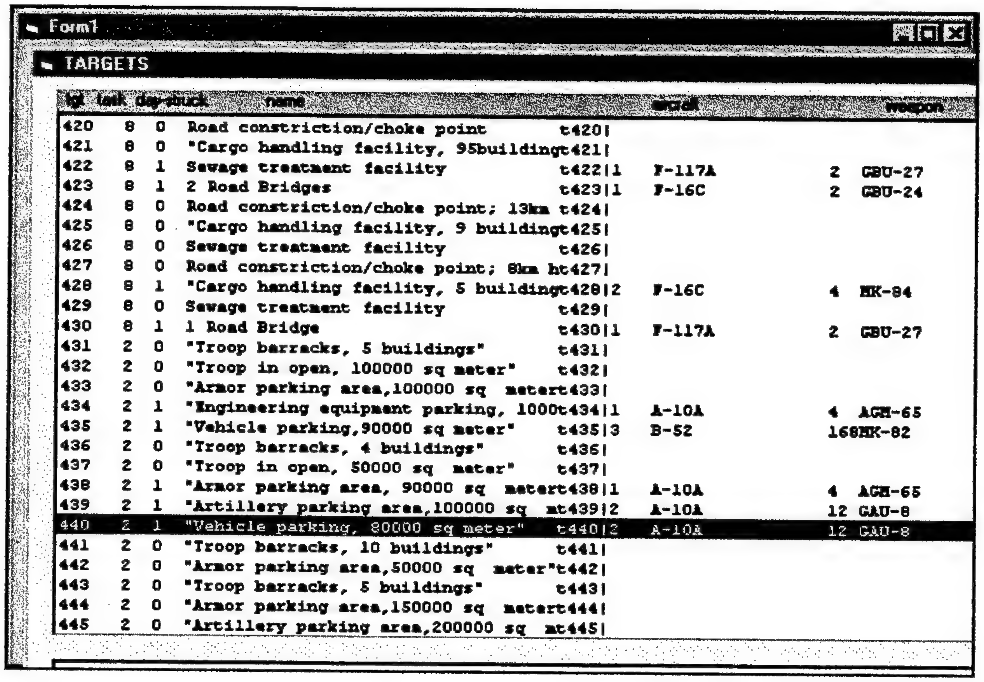

Figure 10. Target Interface After User Specifications

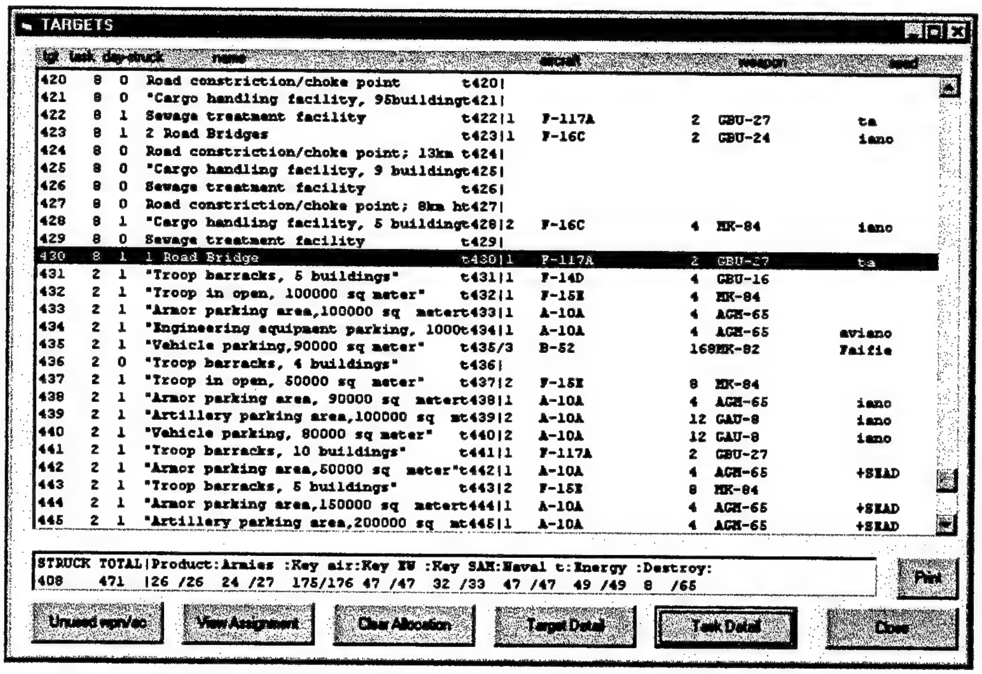

Figure 11. Target Interface After CTEM Run

The buttons located across the bottom of the *Target* interface window provide the planner with other graphical or data representations that can be used to compare strategies.

The *Unused wpn/ac* button displays the number of weapons and aircraft CTEM did not use in the final packaging solution (Figure 12). The "left" column is generally the result of packaging

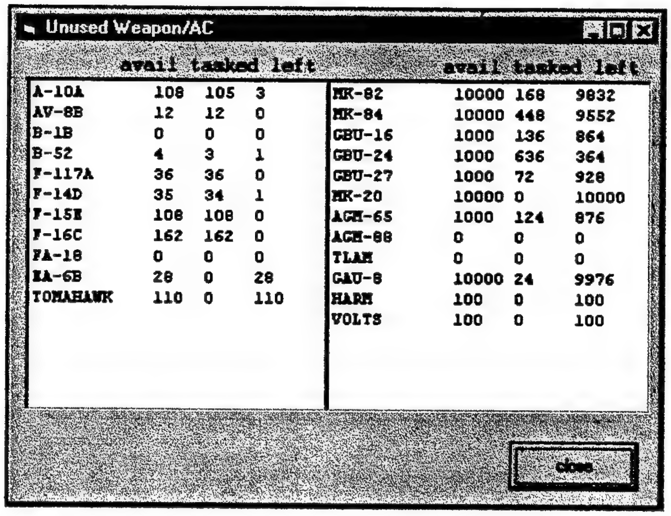

Figure 12. Unused Aircraft and Weapons Data

conflicts the back-end heuristic could not resolve. If the numbers of unused aircraft are high, then some severe conflicts may exist in the targeting or the dispersion factors may be set to encompass to small an area.

The *View Assignment* button displays a graphical representation of the target categories, packages, tasks, TOTs, aircraft, and weapons. The user can display lists of targets selected for strike by CTEM and those that were not selected. The user has access to target summary detail upon request and can graphically display the threat grid. Finally, the *View Assignment* screen provides the user with a tool to compute distances between two points on the graphics display. Figure 13 shows the graphical display of package 1 along with the threat grid. The darker squares of the threat grid represents high threat defenses; in ADVISE, high threat areas are color-coded red. The lighter grid

squares, color-coded yellow in ADVISE, represent medium threat defenses. Where no threat grid overlays a target, it is considered as low defended. The targets struck in this package are displayed as the oversized target squares on the graphic. Figure 14 shows the target detail display that can be

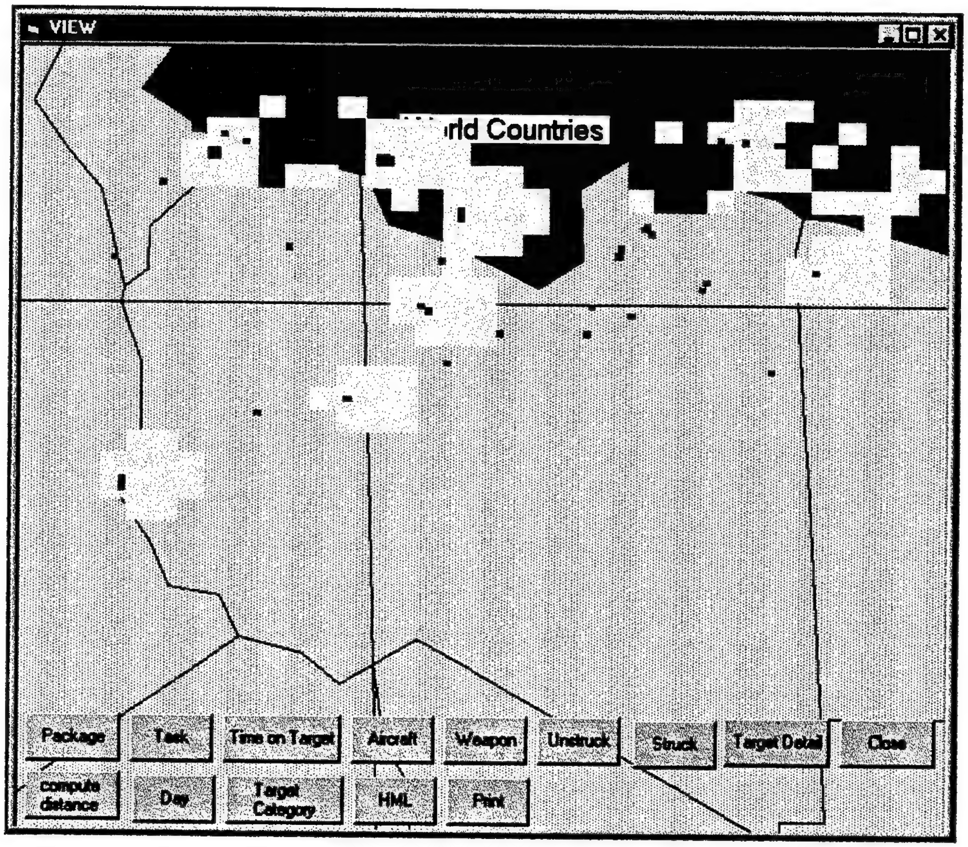

Figure 13. Package 1 Representation Under the View Assignments Button

accessed upon the planner's request. The information available in this data box is self explanatory.

The *Target Detail* can be accessed from the initial *Target* interface screen as well as from within *Task Detail* (Figure 15) interface. The *Task Detail* presents a data display of how well the solution achieved the desired goals. It can display the data as a percent accomplished, or as the number of sorties tasked versus required, or as the number of targets struck versus the number required to accomplish the goal.

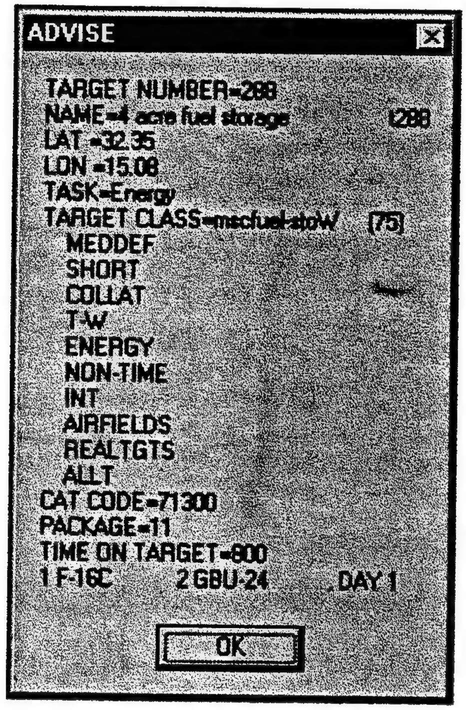

Figure 14. Target Detail

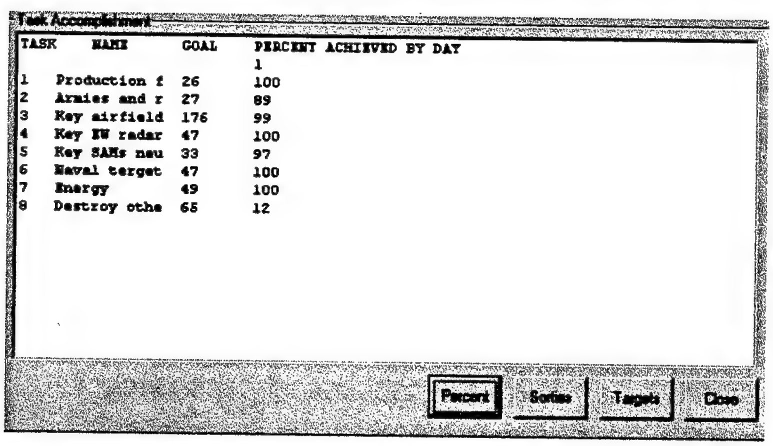

Figure 15. Task Detail

Another display of how well the model achieved the programmed goals is a graphical display reached from the main ADVISE window through the *Task* button. In Figure 16 the bars represent the percent of the goal achieved. Clicking on the number of the task displays detail about the number

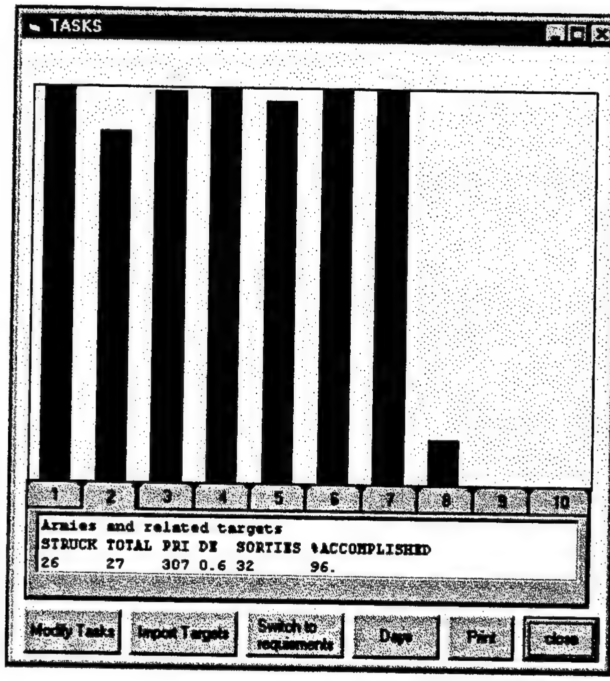

Figure 16. Task Interface Graphic

of targets struck out of the total number of targets assigned to the task, the priority of the task, the number of sorties flown to accomplish the task, and the numerical percent of targets struck. The *Task* interface gives the user quick access to analyze how well the plan accomplished its objectives. The *Modify Tasks* and *Import Target* buttons are available only when *Advanced Controls* are selected and are self explanatory.

4.2.2 Weapons and Aircraft

The *Weapons* button allows the user to change the number of weapons available. Figure 17 shows the graphical user interface created by ADVISE to edit the weapons data. The *Weapons Effects* button indicated by the arrow only appears when the *advanced controls* button is activated.

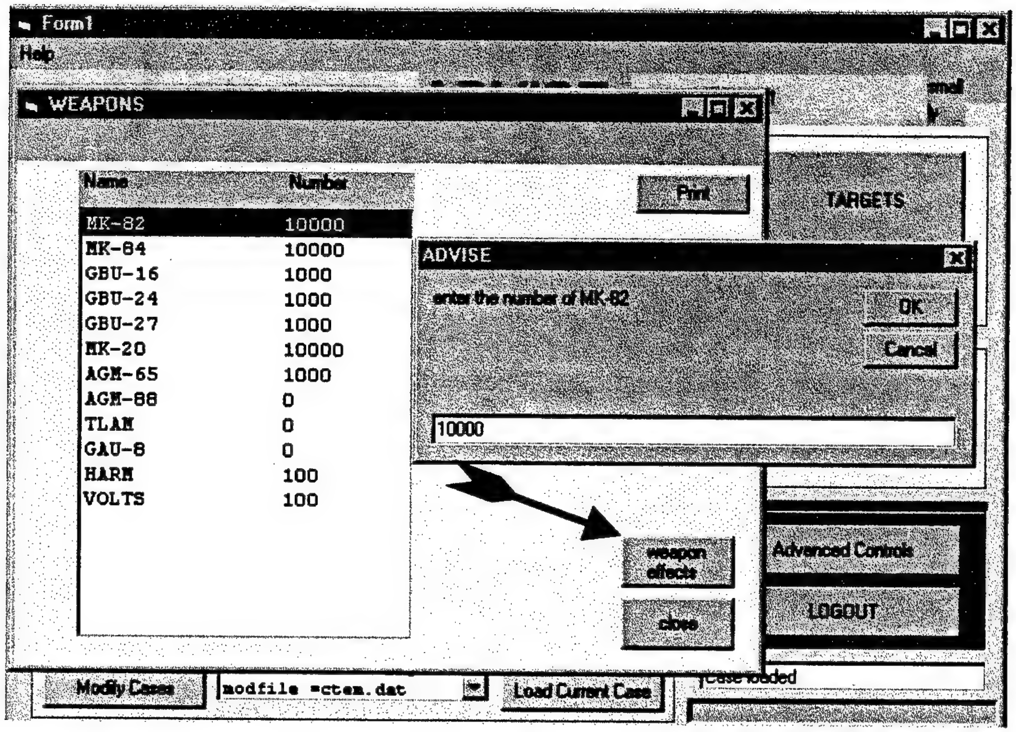

Figure 17. Weapons Interface

The *Weapons Effects* button brings up another window (Figure 18) that displays the PD of an aircraft/weapon/target combination. This provides the planner with easy access to the PDs as determined by DOMOD.

The *Aircraft* button in ADVISE is very similar to the *Weapons* Button; it provides a way to change the number of aircraft available or the sortie rate of a particular aircraft type (Figure 19). It provides a quick and easy way for the planner to check the sensitivity of the solution to the number of aircraft available.

4.2.3 Using ADVISE

ADVISE gives the user a graphical interface into CTEM that allows the user to specify strategies that are dictated by factors not explicitly defined in the model. The user is given tools to evaluate the choices made and can build multiple cases. With ADVISE, a planner can allocate specific aircraft configurations against targets based on tactics, terrain or specific capabilities of the weapon system against a known threat. The planner tailors the plan to the tactical situation. When all the unique situations are covered (this may be a few or all the targets), CTEM can be run to fill in the remaining allocations and perform the packaging. Then the planners can examine the results and determine if the goals were adequately achieved, or if the goals, or allocations need to be changed.

ADVISE provides a capability to examine some sensitivity of the problem. Planners can see how changes to the number of aircraft, sortie rates, or weapons availability affects the plan. Some changes may affect the plan very little while others can cause most of the allocations to change. Any strategy specified by the user will not change unless the user makes the change. Therefore, planners can ensure strikes on critical targets.

Another benefit of using ADVISE is that it gives the planner more insight into how CTEM performs; the better the user knows CTEM, the better the expected result. By using a graphical

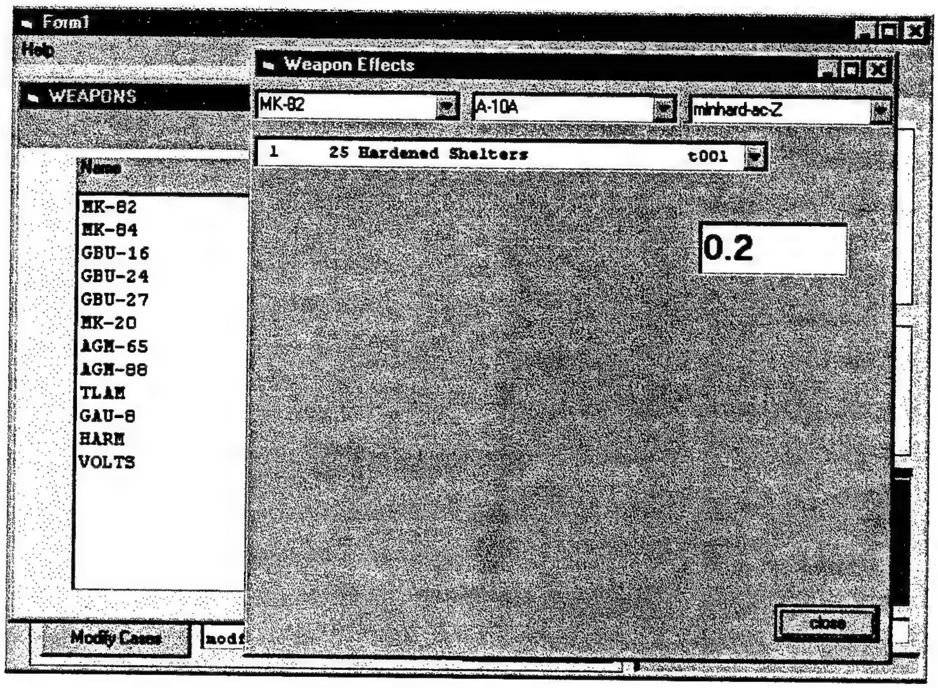

Figure 18. Advanced Weapons Interface

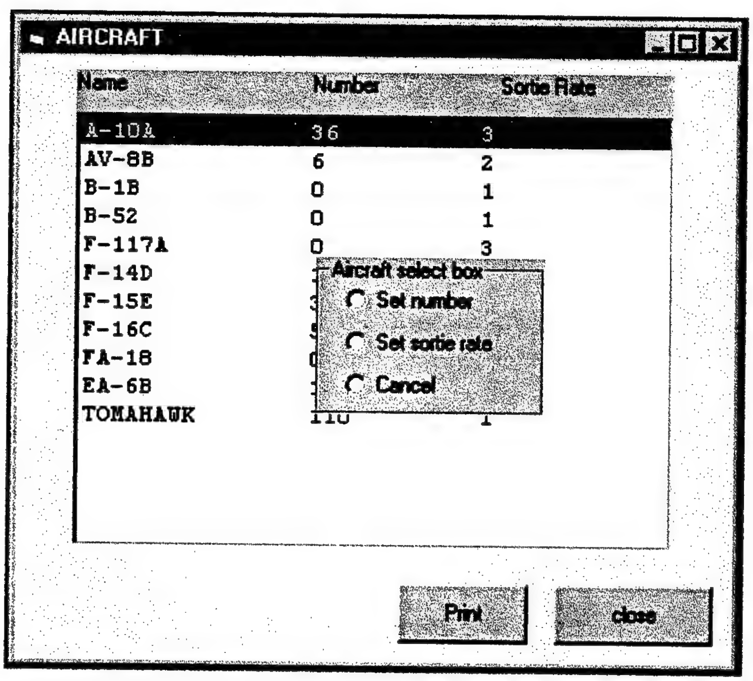

Figure 19. Aircraft Interface

interface, most pilots can quickly learn how to use ADVISE. It takes some of the mystery out of the model and has a good chance at passing the "pilot simplicity test": can I use this to get a good solution faster than doing it manually.

Chapter 5 - Summary

Air campaign planning is a complex problem involving many decisions and judgements about uncertainty. Chapter 2 examined the theoretical air campaign planning process as well as the planning process used in Operation Desert Storm. Campaign planning entails making choices:

- Choosing proper objectives based on national policies, theater goals and operational objectives,
- Choosing the correct strategies to accomplish the objectives; those that apply our strengths against the enemy's weaknesses,
- Choosing the proper centers of gravity, and
- Choosing the right target, right weapon system and applying them in the right sequence. [15, 8]

The planner must sift through enormous quantities of information to reduce the uncertainties in the process providing better plans.

The current system, CTAPS, is a collection of mostly stand-alone applications that have been modified to run together with minimum interference. It is more of a data manipulator; planners use it to produce and disseminate the ATO. CTAPS provides some planning tools for route planning and weaponeering, but developing the MAAP was still a manual, time-consuming process during Operation Desert Storm averaging over eleven hours per planning cycle. The MAAP provides the required input for CTAPS. Finding solutions to speeding up the development of the MAAP is seen as key to reducing the length of the planning cycle and making it more responsive to the dynamic combat environment.

The types of decisions required in building a MAAP to achieve a set of objectives is combinatorial in nature and computationally difficult. Mathematical programming offers a very viable tool to solve this problem. AEM Services, Inc. modified a well-used force analysis model, the Arsenal Exchange Model, for use in conventional weapons analysis. The new model, CTEM, represents the problem as an LP. CTEM solves the LP and then uses "smart rounding" to obtain integer values for variables that cannot have fractional assignments. This is a standard technique used in operations

research and makes sense in air campaign planning because the mathematical optimal solution is not necessarily the best practical solution.

CTEM optimizes on the primary uncertainty of probability of damage. The idea is to cause the most damage for the least cost. However, objectives can be achieved by non-destructive means such as denying communications through the use of electronics and in some situations such tactics may be more appropriate.

CTEM uses a goal programming approach that matches up well with the objective-driven air campaign planning process. The users must translate military objectives into mathematical ones that CTEM can solve. CTEM uses a wide range of inputs and constraints that allow users to tailor the problem to the military situation. It is a rather complex model that is not easily understood by the average planner.

The mathematical model makes several assumptions to simplify the problem and make it solvable. Users of the model must be aware of these assumptions because the combat environment is very dynamic and unpredictable. Clausewitz spoke of the "fog of war" and today's generals have described the air campaign as "managing chaos" [16, 140] [7, Part II, 229]. Planners must compensate for changes required by the tactical situation or operational art that the model does not explicitly address.

The MAAP problem can quickly grow beyond the capability of current computer technology for solution in a reasonable amount of time. Therefore, CTEM uses aggregation to reduce the number of variables. CTEM's treatment of enemy threats is an area where aggregation is used. Aggregation reduces the fidelity of the model and this is where it departs from the manual expert approach. Weapons systems experts are adept at exploiting a particular platform's strength against a specific threat weakness. CTEM blurs these match-ups through aggregation resulting in a general war of attrition. It exploits probabilities not tactics and the probabilities become generalized through

aggregation. This approach allows the problem to be solved in a reasonable time and provides a good estimation for military and political leaders. However, it is not adequate for preparing a daily MAAP.

The JPT aggregates the data even further by presetting many of the input variables in an attempt to simplify using CTEM. SEAD becomes a {0,1} or on-off decision, and the real power of the CTEM, hedging, is limited. Each aircraft is limited to one target and the PD data is out of date. The JPT was never intended as a 1-2-3 cookbook, and requires the user to think critically and analyze the information presented [1, 4].

To help the user interact or collaborate with CTEM, a new program, ADVISE, has been developed to incorporate collaborative planning. Collaborative planning allows the user to specify all or parts of the plan through graphical interfaces. It presents the results in a graphical manner that users can evaluate easily and then modify the input to "tweak" the solution. It gives the planner insight into how the model works and permits him to modify it to compensate for tactical situations that the model is unable to address. Its simple format gives all potential users the ability to work with it. There is value gained from familiarity. The more familiar users become with the model, the better the results.

Operations research has been applied to MAAP automation with mixed results. Air Force Manual 1-1, Basic Aerospace Doctrine, reminds us that, "Because of their specialized competence, airmen must play a key role in the employment of aerospace power"[2, 126]. The collaborative planning heeds this advice. Doctrine also states that, "There is no universal formula for the proper employment of aerospace power in a campaign" [2, 125]. This is one of the reasons why modeling the air campaign planning process is so difficult. For any situation where the model performs well, another exists where it will not perform well. Collaborative planning is the first step in letting the experts override the model when it performs poorly for a given situation.

Finally, AFM 1-1 warns that

"In general, war can not be won by the rote application of military science. Rather, war is successfully waged by those who use the foundation provided by military science, but who actually plan, deploy and employ forces based on creative thought and the ability to deal with abstractions rather than the technical skills and hard data points required by military science."

Any analyst applying operations research to the air campaign planning process must give the experts the ability to understand and interface with the tools or they will not be used. MAAP automation is limited to providing tools that help the planner make choices by presenting information in a quick and easily understood format. The expert still needs to apply "operational art" to the problem. The technology is not yet ripe for the machine to supplant the operator in the planning loop, its merely ready to provide support.

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APPENDIX A - Complete CTEM Generated MAAP

MASTER ATTACK PLAN FOR DAY 1

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION		MSN	#	AC	#	WPN	SEAD		
0000	1	4	241059N	231900E	9006AB0001	25 Hardened Shelters	t001	INT	1	F-15E	4	GBU-24	0	1	.9744
0000	2	4	241059N	231900E	9006AB0002	23 Revetments	t002	INT	1	F-16C	2	GBU-24	0	2	.9900
0000	3	4	241059N	231900E	9006AB0003	8000 sq meters fuel storage	t003	INT	1	F-16C	2	GBU-24	0	3	.9900
0000	4	4	241059N	231900E	9006AB0004	10 Munitions storage bunkers	t004	INT	1	F-14D	4	GBU-16	0	4	.9744
0000	5	4	241059N	231900E	9006AB0005	4 Maintenance buildings	t005	INT	1	F-14D	4	GBU-16	0	5	.9744
0000	6	4	241059N	231900E	9006AB0006	"2 Concrete RWY, 4 Asp TXWY"	t006	INT	1	A-10A	4	MK-84	102	6	.4999
0000	7	4	241059N	231900E	9006AB0007	"2 Command bunkers, 13 Housing/Ops b	t007	INT	1	F-15E	4	GBU-24	0	7	.9084
0000	8	2	320659N	201659E	9003AB0008	20 Hardened Shelters	t008	INT	1	F-15E	4	GBU-24	102	8	.0000
0000	9	2	320659N	201659E	9003AB0009	30 Revetments	t009	INT	1	AV-8B	4	AGM-65	102	9	.8998
0000	10	2	320659N	201659E	9003AB0010	8000 sq meters fuel storage	t010	INT	1	F-16C	2	GBU-24	102	10	.0000
0000	11	2	320659N	201659E	9003AB0011	15 Munitions storage bunkers	t011	INT	1	A-10A	4	MK-84	102	11	.7998
0000	12	2	320659N	201659E	9003AB0012	7 Maintenance buildings	t012	INT	1	F-117A	2	GBU-27	0	12	.9900
0000	13	2	320659N	201659E	9003AB0013	"2 Concrete RWY, 5 Asp TXWY"	t013	INT	2	A-10A	8	MK-84	102	13	.7499
0000	14	2	320659N	201659E	9003AB0014	"2 Command bunkers, 15 Housing/Ops b	t014	INT	1	F-15E	4	GBU-24	102	14	.0000
0000	15	3	315100N	235500E	9003AB0015	25 Hardened Shelters	t015	INT	1	F-15E	4	GBU-24	102	15	.0000
0000	16	3	315100N	235500E	9003AB0016	20 Revetments	t016	INT	1	AV-8B	4	AGM-65	102	16	.8998
0000	17	3	315100N	235500E	9003AB0017	8000 sq meters fuel storage	t017	INT	1	F-16C	2	GBU-24	102	17	.9900
0000	18	3	315100N	235500E	9003AB0018	8 Munitions storage bunkers	t018	INT	1	A-10A	4	MK-84	102	18	.7998
0000	19	3	315100N	235500E	9003AB0019	8 Maintenance buildings	t019	INT	1	F-117A	2	GBU-27	0	19	.9900
0000	20	3	315100N	235500E	9003AB0020	"3 Concrete RWY, 5 Asp TXWY"	t020	INT	2	A-10A	8	MK-84	102	20	.7499
0000	21	3	315100N	235500E	9003AB0021	"1 Command bunker, 7 Housing/Ops bui	t021	INT	1	F-15E	4	GBU-24	102	21	.0000
0000	22	6	250759N	101059E	9004AB0029	30 Hardened Shelters	t022	INT	1	F-15E	4	GBU-24	0	22	.9744
0000	23	6	250759N	101059E	9004AB0030	11 Revetments	t023	INT	1	F-16C	2	GBU-24	0	23	.9900
0000	24	6	250759N	101059E	9004AB0031	8000 sq meters fuel storage	t024	INT	1	F-16C	2	GBU-24	0	24	.9900
0000	25	6	250759N	101059E	9046AB0033	2 Maintenance buildings	t026	INT	1	F-16C	2	GBU-24	0	26	.8399
0000	26	6	250759N	101059E	9004AB0034	"4 Asp RWY, 4 Asp TXWY"	t027	INT	2	A-10A	8	MK-84	102	27	.7499
0000	27	6	250759N	101059E	9004AB0035	"1 Command bunker, 5 Housing/Ops bui	t028	INT	1	F-15E	4	GBU-24	0	28	.9084
0000	28	5	310459N	163459E	9002AB0057	30 Hardened Shelters	t029	INT	1	F-15E	4	GBU-24	0	29	.9744
0000	29	5	310459N	163459E	9002AB0058	21 Revetments	t030	INT	1	F-16C	2	GBU-24	0	30	.9900
0000	30	5	310459N	163459E	9002AB0059	4 acre fuel storage	t031	INT	1	F-16C	2	GBU-24	0	31	.9900
0000	31	5	310459N	163459E	9002AB0060	7 Munitions storage bunkers	t032	INT	1	F-14D	4	GBU-16	0	32	.9744
0000	32	5	310459N	163459E	9002AB0061	6 Maintenance buildings	t033	INT	1	F-14D	4	GBU-16	0	33	.9744
0000	33	5	310459N	163459E	9002AB0062	"3 Concrete RWY, 4 Asp TXWY"	t034	INT	2	A-10A	8	MK-84	102	34	.0000
0000	34	5	310459N	163459E	9002AB0063	"2 Command bunkers, 9 Housing/Ops bu	t035	INT	1	F-15E	4	GBU-24	0	35	.9084
0000	35	1	322059N	150459E	9002AB0036	40 Hardened Shelters	t036	INT	1	F-15E	4	GBU-24	0	36	.9744
0000	36	1	322059N	150459E	9002AB0037	9 Revetments	t037	INT	1	F-16C	2	GBU-24	0	37	.9900
0000	37	1	322059N	150459E	9002AB0038	4 acre fuel storage	t038	INT	1	F-16C	2	GBU-24	0	38	.9900
0000	38	1	322059N	150459E	9002AB0039	4 Munitions storage bunkers	t039	INT	1	F-14D	4	GBU-16	0	39	.9744
0000	39	1	322059N	150459E	9002AB0040	4 Maintenance buildings	t040	INT	1	F-14D	4	GBU-16	0	40	.9744
0000	40	1	322059N	150459E	9002AB0041	"2 Concrete RWY, 2 Asp TXWY"	t041	INT	2	A-10A	8	MK-84	102	41	.7499
0000	41	1	322059N	150459E	9002AB0042	"2 Command bunkers, 6 Housing/Ops bu	t042	INT	1	F-15E	4	GBU-24	0	42	.9084
0000	42	1	322859N	115259E	9001AB0043	37 Hardened Shelters	t043	INT	1	F-15E	4	GBU-24	0	43	.9744
0000	43	1	322859N	115259E	9001AB0044	32 Revetments	t044	INT	1	F-16C	2	GBU-24	0	44	.9900
0000	44	1	322859N	115259E	9001AB0045	4 acre fuel storage	t045	INT	1	F-16C	2	GBU-24	0	45	.9900
0000	45	1	322859N	115259E	9001AB0046	5 Munitions storage bunkers	t046	INT	1	F-14D	4	GBU-16	0	46	.9744
0000	46	1	322859N	115259E	9001AB0047	5 Maintenance buildings	t047	INT	1	F-14D	4	GBU-16	0	47	.9744
0000	47	1	322859N	115259E	9001AB0048	"2 Concrete RWY, 3 Asp TXWY"	t048	INT	2	A-10A	8	MK-84	102	48	.0000
0000	48	1	322859N	115259E	9001AB0049	"1 Command bunker, 7 Housing/Ops bui	t049	INT	1	F-15E	4	GBU-24	0	49	.9084
0000	49	7	270000N	142559E	9005AB0050	25 Hardened Shelters	t050	INT	1	F-15E	4	GBU-24	0	50	.9744
0000	50	7	270000N	142559E	9005AB0051	8 Revetments	t051	INT	1	F-16C	2	GBU-24	0	51	.9900
0000	51	7	270000N	142559E	9005AB0052	12000 sq meters fuel storage	t052	INT	1	F-16C	2	GBU-24	0	52	.9900
0000	52	7	270000N	142559E	9005AB0053	5 Munitions storage bunkers	t053	INT	1	F-14D	4	GBU-16	0	53	.9744
0000	53	7	270000N	142559E	9005AB0054	5 Maintenance buildings	t054	INT	1	F-14D	4	GBU-16	0	54	.9744

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION		MSN	# AC	# WPN	SEAD		
0000	54	7	270000N	142559E	9005AB0055	"2 Concrete RWY, 3 Asp TXWY"	t055	INT	2 A-10A	8 MK-84	102	55	.0000
0000	55	7	270000N	142559E	9005AB0056	"2 Command bunkers, 8 Housing/Ops bu	t056	INT	1 F-15E	4 GBU-24	0	56	.9084
0000	56	1	324000N	130759E	9001AB0064	35 Hardened Shelters	t057	INT	1 F-15E	4 GBU-24	102	57	.9744
0000	57	1	324000N	130759E	9001AB0065	25 Revetments	t058	INT	1 AV-8B	4 AGM-65	102	58	.8998
0000	58	1	324000N	130759E	9001AB0066	4 acre fuel storage	t059	INT	1 F-16C	2 GBU-24	102	59	.9900
0000	59	1	324000N	130759E	9001AB0067	19 Munitions storage bunkers	t060	INT	1 A-10A	4 MK-84	102	60	.7998
0000	60	1	324000N	130759E	9001AB0068	8 Maintenance buildings	t061	INT	1 F-117A	2 GBU-27	0	61	.9900
0000	61	1	324000N	130759E	9001AB0069	"2 Concrete RWY, 3 Asp TXWY"	t062	INT	2 A-10A	8 MK-84	102	62	.7499
0000	62	1	324000N	130759E	9001AB0070	"2 Command bunkers, 10 Housing/Ops b	t063	INT	1 F-15E	4 GBU-24	102	63	.0000
0000	63	1	325500N	131659E	9001AB0071	25 Hardened Shelters	t064	INT	1 F-15E	4 GBU-24	102	64	.9744
0000	64	1	325500N	131659E	9001AB0072	27 Revetments	t065	INT	1 A-10A	4 AGM-65	102	65	.8998
0000	65	1	325500N	131659E	9001AB0073	4 acre fuel storage	t066	INT	1 F-16C	2 GBU-24	102	66	.0000
0000	66	1	325500N	131659E	9001AB0074	10 Munitions storage bunkers	t067	INT	1 A-10A	4 MK-84	102	67	.7998
0000	67	1	325500N	131659E	9001AB0075	8 Maintenance buildings	t068	INT	1 F-117A	2 GBU-27	0	68	.9900
0000	68	1	325500N	131659E	9001AB0076	"2 Concrete RWY, 3 Asp TXWY"	t069	INT	2 A-10A	8 MK-84	102	69	.0000
0000	69	1	325500N	131659E	9001AB0077	"1 Command bunker, 7 Housing/Ops bui	t070	INT	1 F-15E	4 GBU-24	102	70	.0000
0000	70	4	241059N	231900E	9006AB0001	25 Hardened Shelters	t071	INT	1 F-15E	4 GBU-24	0	71	.9744
0000	71	4	241059N	231900E	9006AB0002	23 Revetments	t072	INT	1 F-16C	2 GBU-24	0	72	.9900
0000	72	4	241059N	231900E	9006AB0003	8000 sq meters fuel storage	t073	INT	1 F-16C	2 GBU-24	0	73	.9900
0000	73	4	241059N	231900E	9006AB0004	10 Munitions storage bunkers	t074	INT	1 F-14D	4 GBU-16	0	74	.9744
0000	74	4	241059N	231900E	9006AB0005	4 Maintenance buildings	t075	INT	1 F-14D	4 GBU-16	0	75	.9744
0000	75	4	241059N	231900E	9006AB0006	"2 Concrete RWY, 4 Asp TXWY"	t076	INT	1 A-10A	4 MK-84	102	76	.4999
0000	76	4	241059N	231900E	9006AB0007	"2 Command bunkers, 13 Housing/Ops b	t077	INT	1 F-15E	4 GBU-24	0	77	.9084
0000	77	2	320659N	201659E	9003AB0008	20 Hardened Shelters	t078	INT	1 F-15E	4 GBU-24	102	78	.9744
0000	78	2	320659N	201659E	9003AB0009	30 Revetments	t079	INT	1 A-10A	4 AGM-65	102	79	.8998
0000	79	2	320659N	201659E	9003AB0010	8000 sq meters fuel storage	t080	INT	1 F-16C	2 GBU-24	102	80	.0000
0000	80	2	320659N	201659E	9003AB0012	7 Maintenance buildings	t082	INT	1 F-117A	2 GBU-27	0	82	.9900
0000	81	2	320659N	201659E	9003AB0014	"2 Command bunkers, 15 Housing/Ops b	t084	INT	1 F-15E	4 GBU-24	102	84	.0000
0000	82	3	315100N	235500E	9003AB0015	25 Hardened Shelters	t085	INT	1 F-15E	4 GBU-24	102	85	.0000
0000	83	3	315100N	235500E	9003AB0016	20 Revetments	t086	INT	1 AV-8B	4 AGM-65	102	86	.8998
0000	84	3	315100N	235500E	9003AB0017	8000 sq meters fuel storage	t087	INT	1 F-16C	2 GBU-24	102	87	.0000
0000	85	3	315100N	235500E	9003AB0018	8 Munitions storage bunkers	t088	INT	1 A-10A	4 MK-84	102	88	.7998
0000	86	3	315100N	235500E	9003AB0019	8 Maintenance buildings	t089	INT	1 F-117A	2 GBU-27	0	89	.9900
0000	87	3	315100N	235500E	9003AB0021	"1 Command bunker, 7 Housing/Ops bui	t091	INT	1 F-15E	4 GBU-24	102	91	.0000
0000	88	6	250759N	101059E	9004AB0029	30 Hardened Shelters	t092	INT	1 F-15E	4 GBU-24	0	92	.9744
0000	89	6	250759N	101059E	9004AB0030	11 Revetments	t093	INT	1 F-16C	2 GBU-24	0	93	.9900
0000	90	6	250759N	101059E	9004AB0031	8000 sq meters fuel storage	t094	INT	1 F-16C	2 GBU-24	0	94	.9900
0000	91	6	250759N	101059E	9046AB0033	2 Maintenance buildings	t096	INT	1 F-16C	2 GBU-24	0	96	.8399
0000	92	6	250759N	101059E	9004AB0035	"1 Command bunker, 5 Housing/Ops bui	t098	INT	1 F-15E	4 GBU-24	0	98	.9084
0000	93	5	310459N	163459E	9002AB0057	30 Hardened Shelters	t099	INT	1 F-15E	4 GBU-24	0	99	.9744
0000	94	5	310459N	163459E	9002AB0058	21 Revetments	t100	INT	1 F-16C	2 GBU-24	0	100	.9900
0000	95	5	310459N	163459E	9002AB0059	4 acre fuel storage	t101	INT	1 F-16C	2 GBU-24	0	101	.9900
0000	96	5	310459N	163459E	9002AB0061	6 Maintenance buildings	t103	INT	1 F-16C	2 GBU-24	0	103	.8399
0000	97	5	310459N	163459E	9002AB0063	"2 Command bunkers, 9 Housing/Ops bu	t105	INT	1 F-15E	4 GBU-24	0	105	.9084
0000	98	1	322059N	150459E	9002AB0036	40 Hardened Shelters	t106	INT	1 F-15E	4 GBU-24	0	106	.9744
0000	99	1	322059N	150459E	9002AB0037	9 Revetments	t107	INT	1 F-16C	2 GBU-24	0	107	.9900
0000	100	1	322059N	150459E	9002AB0038	4 acre fuel storage	t108	INT	1 F-16C	2 GBU-24	0	108	.9900
0000	101	1	322059N	150459E	9002AB0042	"2 Command bunkers, 6 Housing/Ops bu	t112	INT	1 F-15E	4 GBU-24	0	112	.9084
0000	102	1	322859N	115259E	9001AB0043	37 Hardened Shelters	t113	INT	1 F-15E	4 GBU-24	0	113	.9744
0000	103	1	322859N	115259E	9001AB0049	"1 Command bunker, 7 Housing/Ops bui	t119	INT	1 F-15E	4 GBU-24	0	119	.9084
0000	104	7	270000N	142559E	9005AB0050	25 Hardened Shelters	t120	INT	1 F-15E	4 GBU-24	0	120	.9744
0000	105	7	270000N	142559E	9005AB0056	"2 Command bunkers, 8 Housing/Ops bui126		INT	1 F-15E	4 GBU-24	0	126	.9084
0000	106	1	324000N	130759E	9001AB0065	25 Revetments	t128	INT	1 A-10A	4 AGM-65	102	128	.8998
0000	107	1	324000N	130759E	9001AB0066	4 acre fuel storage	t129	INT	1 F-16C	2 GBU-24	102	129	.9900

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION		MSN	#	AC	#	WPN	SEAD		
0000	108	1	324000N	130759E	9001AB0068	8 Maintenance buildings	t131	INT	1	F-117A	2	GBU-27	0	131	.9900
0000	109	1	325500N	131659E	9001AB0073	4 acre fuel storage	t136	INT	1	F-16C	2	GBU-24	102	136	.9900
0000	110	1	325500N	131659E	9001AB0075	8 Maintenance buildings	t138	INT	1	F-117A	2	GBU-27	0	138	.9900
0000	111	2	304500N	201200E	9003PF0184	Gas Turbine Powerplant; 1 Unit	t141		1	F-16C	2	GBU-24	0	141	.8399
0000	112	9	295359N	231959E	9003PF0180	Electrical Switching Relay Station;	t142		1	F-16C	2	GBU-24	0	142	.9900
0000	113	2	305200N	200400E	9003PF0191	Diesel Powerplant; 1 Unit	t153		1	F-16C	2	GBU-24	0	153	.8399
0000	114	2	321000N	200459E	9003PF0192	Electrical Switching Relay Station;	t154		1	F-16C	2	GBU-24	102	154	.0000
0000	115	2	303459N	182700E	9002PF0213	Gas Turbine Powerplant; 1 Unit	t160		1	F-16C	2	GBU-24	0	160	.8399
0000	116	5	310400N	163459E	9002PF0205	Electrical Switching Relay Station;	t166		1	F-16C	2	GBU-24	0	166	.9900
0000	117	2	302500N	193759E	9002PF0207	Diesel Powerplant; 1 Unit	t168		1	F-16C	2	GBU-24	0	168	.8399
0000	118	1	324959N	131500E	9001PF0221	Gas Turbine Powerplant; 1 Unit	t178		1	F-16C	2	GBU-24	102	178	.8399
0000	119	3	320459N	235500E	9003PF0217	Electrical Switching Relay Station;	t182		1	F-16C	2	GBU-24	102	182	.0000
0000	120	2	301500N	193459E	9002PF0429	"Petroleum Refinery and Terminal, 6	t188		1	F-16C	2	GBU-24	0	188	.8399
0000	121	2	304000N	181959E	9002PF0431	"Petroleum Refinery and Terminal, 4	t190		1	F-16C	2	GBU-24	0	190	.8399
0000	122	3	320000N	240459E	9003PF0417	"Petroleum Refinery and Terminal, 5	t194		1	F-16C	2	GBU-24	102	194	.8399
0000	123	2	305500N	200700E	9003PF0419	"Petroleum Refinery and Terminal, 3	t196		1	F-16C	2	GBU-24	0	196	.8399
0000	124	10	285500N	194959E	9002PF0423	"400 Km Pipeline, 3 pumping stations	t200		1	F-16C	2	GBU-24	0	200	.9900
0000	125	10	290700N	190459E	9002PF0424	"450 Km Pipeline, 3 pumping stations	t201		1	F-16C	2	GBU-24	0	201	.9900
0000	126	2	304500N	201200E	9003SF0258	"Ammunition Storage; 11 earthen bunk	t204	INT	1	F-16C	2	GBU-24	0	204	.9900
0000	127	2	321000N	200459E	9003SF0304	"Food Storage; 17 buildings, 28000 s	t215	INT	1	F-117A	2	GBU-27	0	215	.9900
0000	128	2	320659N	201659E	9003AB0009	30 Revetments	t259	INT	1	AV-8B	4	AGM-65	102	259	.8998
0000	129	2	320659N	201659E	9003AB0012	7 Maintenance buildings	t262	INT	1	F-117A	2	GBU-27	0	262	.9900
0000	130	3	320459N	240000E	9003SP0316	4 Docks	t338		1	F-16C	2	GBU-24	102	338	.9900
0000	131	9	295359N	231959E	9003IA0227	SA-2	t367		1	F-16C	2	GBU-24	0	367	.9900
0000	132	2	321000N	200459E	9003IA0232	SA-5	t379		1	F-16C	2	GBU-24	102	379	.0000
0000	133	1	324000N	130759E	9001IA0251	EW Radar site; 7 buildings	t404		1	AV-8B	4	AGM-65	102	404	.8998
0000	134	3	320000N	240000E	9003IA0383	SA-3	t408		1	F-16C	2	GBU-24	102	408	.9900
0000	135	1	321959N	150959E	9002TI0350	Sewage treatment facility	t422	INT	1	F-117A	2	GBU-27	0	422	.9900
0000	136	1	324959N	133000E	9001TI0336	2 Road Bridges	t423	INT	1	F-16C	2	GBU-24	0	423	.0000
0000	137	3	320459N	240000E	9003TI0346	"Cargo handling facility, 5 building	t428	INT	2	F-16C	4	MK-84	0	428	.0000
0000	138	1	330459N	113459E	9001TI0335	1 Road Bridge	t430	INT	1	F-117A	2	GBU-27	0	430	.7499
0000	139	8	274959N	161959E	9005MA0354	"Armor parking area,100000 sq meter	t433	CAS	1	A-10A	4	AGM-65	0	433	.8998
0000	140	8	274959N	161959E	9005MA0355	"Engineering equipment parking, 1000	t434	CAS	1	A-10A	4	AGM-65	0	434	.8998
0000	141	8	274959N	161959E	9005MA0368	"Vehicle parking,90000 sq meter"	t435	CAS	3	B-52	168	MK-82	0	435	.6569
0000	142	4	234959N	230959E	9006MA0361	"Armor parking area, 90000 sq meter	t438	CAS	1	A-10A	4	AGM-65	0	438	.0000
0000	143	4	234959N	230959E	9006MA0362	"Artillery parking area,100000 sq m	t439	CAS	2	A-10A	12	GAU-8	0	439	.0000
0000	144	4	234959N	230959E	9006MA0370	"Vehicle parking, 80000 sq meter"	t440	CAS	2	A-10A	12	GAU-8	0	440	.0000
0800	145	12	320659N	201659E	9003AB0011	15 Munitions storage bunkers	t081	INT	1	A-10A	4	MK-84	102	81	.7998
0800	146	12	320659N	201659E	9003AB0013	"2 Concrete RWY, 5 Asp TXWY"	t083	INT	2	A-10A	8	MK-84	102	83	.7499
0800	147	13	315100N	235500E	9003AB0020	"3 Concrete RWY, 5 Asp TXWY"	t090	INT	2	A-10A	8	MK-84	102	90	.0000
0800	148	14	250759N	101059E	9004AB0032	2 Munitions storage bunkers	t095	INT	1	F-14D	4	GBU-16	0	95	.9744
0800	149	14	250759N	101059E	9004AB0034	"4 Asp RWY, 4 Asp TXWY"	t097	INT	2	A-10A	8	MK-84	102	97	.0000
0800	150	15	310459N	163459E	9002AB0060	7 Munitions storage bunkers	t102	INT	1	F-14D	4	GBU-16	0	102	.9744
0800	151	15	310459N	163459E	9002AB0062	"3 Concrete RWY, 4 Asp TXWY"	t104	INT	2	A-10A	8	MK-84	102	104	.0000
0800	152	11	322059N	150459E	9002AB0039	4 Munitions storage bunkers	t109	INT	1	F-14D	4	GBU-16	0	109	.9744
0800	153	11	322059N	150459E	9002AB0040	4 Maintenance buildings	t110	INT	1	F-14D	4	GBU-16	0	110	.9744
0800	154	11	322059N	150459E	9002AB0041	"2 Concrete RWY, 2 Asp TXWY"	t111	INT	2	A-10A	8	MK-84	102	111	.0000
0800	155	11	322859N	115259E	9001AB0044	32 Revetments	t114	INT	1	F-16C	2	GBU-24	0	114	.9900
0800	156	11	322859N	115259E	9001AB0045	4 acre fuel storage	t115	INT	1	F-16C	2	GBU-24	0	115	.9900
0800	157	11	322859N	115259E	9001AB0046	5 Munitions storage bunkers	t116	INT	1	F-14D	4	GBU-16	0	116	.9744
0800	158	11	322859N	115259E	9001AB0047	5 Maintenance buildings	t117	INT	1	F-14D	4	GBU-16	0	117	.9744
0800	159	11	322859N	115259E	9001AB0048	"2 Concrete RWY, 3 Asp TXWY"	t118	INT	2	A-10A	8	MK-84	102	118	.0000
0800	160	16	270000N	142559E	9005AB0051	8 Revetments	t121	INT	1	F-16C	2	GBU-24	0	121	.9900
0800	161	16	270000N	142559E	9005AB0052	12000 sq meters fuel storage	t122	INT	1	F-16C	2	GBU-24	0	122	.9900

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION		MSN	# AC		# WPN		SEAD		.
0800	162	16	270000N	142559E	9005AB0053	5 Munitions storage bunkers	t123	INT	1	F-14D	4	GBU-16	0	123	.9744
0800	163	16	270000N	142559E	9005AB0054	5 Maintenance buildings	t124	INT	1	F-14D	4	GBU-16	0	124	.9744
0800	164	16	270000N	142559E	9005AB0055	"2 Concrete RWY, 3 Asp TXWY"	t125	INT	2	A-10A	8	MK-84	102	125	.0000
0800	165	11	324000N	130759E	9001AB0064	35 Hardened Shelters	t127	INT	1	F-15E	4	GBU-24	102	127	.0000
0800	166	11	324000N	130759E	9001AB0067	19 Munitions storage bunkers	t130	INT	1	A-10A	4	MK-84	102	130	.7998
0800	167	11	324000N	130759E	9001AB0070	"2 Command bunkers, 10 Housing/Ops b	t133	INT	1	F-15E	4	GBU-24	102	133	.0000
0800	168	11	325500N	131659E	9001AB0071	25 Hardened Shelters	t134	INT	1	F-15E	4	GBU-24	102	134	.0000
0800	169	11	325500N	131659E	9001AB0072	27 Revetments	t135	INT	1	A-10A	4	AGM-65	102	135	.8998
0800	170	11	325500N	131659E	9001AB0074	10 Munitions storage bunkers	t137	INT	1	A-10A	4	MK-84	102	137	.7998
0800	171	11	325500N	131659E	9001AB0076	"2 Concrete RWY, 3 Asp TXWY"	t139	INT	2	A-10A	8	MK-84	102	139	.0000
0800	172	11	325500N	131659E	9001AB0077	"1 Command bunker, 7 Housing/Ops bui	t140	INT	1	F-15E	4	GBU-24	102	140	.0000
0800	173	18	295359N	231959E	9003PF0181	Thermal Powerplant; 1 Unit	t143		1	F-15E	4	GBU-24	0	143	.9990
0800	174	18	295359N	231959E	9003PF0182	Transformer yard;300 x 500 meter	t144		3	F-15E	12	MK-84	0	144	.8749
0800	175	12	323459N	230700E	9003PF0183	Gas Turbine Powerplant; 1 Unit	t145		1	F-15E	4	GBU-24	0	145	.9990
0800	176	12	324500N	213000E	9003PF0208	Diesel Powerplant; 1 Unit	t146		1	F-15E	4	GBU-24	0	146	.9990
0800	177	17	290700N	155100E	9002PF0185	Thermal Powerplant; 1 Unit	t147		1	F-15E	4	GBU-24	0	147	.9990
0800	178	17	290700N	155100E	9002PF0186	Transformer yard; 500 x 800 meter	t148		3	F-15E	12	MK-84	0	148	.8749
0800	179	11	323800N	141500E	9002PF0187	Gas Turbine Powerplant; 1 Unit	t149		1	F-15E	4	GBU-24	0	149	.9990
0800	180	11	323800N	141500E	9002PF0189	Transformer yard; 900 x 1300 meter	t151		3	F-15E	12	MK-84	0	151	.8749
0800	181	12	323000N	205359E	9003PF0190	Gas Turbine Powerplant; 1 Unit	t152		1	F-15E	4	GBU-24	102	152	.9990
0800	182	12	321000N	200459E	9003PF0193	Thermal Powerplant; 1 Unit	t155		1	F-15E	4	GBU-24	102	155	.0000
0800	183	12	321000N	200459E	9003PF0194	Transformer yard; 900 x 1300 meter	t156		3	A-10A	12	MK-84	102	156	.0000
0800	184	12	324500N	223759E	9003PF0195	Gas Turbine Powerplant; 1 Unit	t157		1	F-15E	4	GBU-24	102	157	.0000
0800	185	12	324500N	223759E	9003PF0196	Transformer yard; 500 x 1000 meter	t158		3	A-10A	12	MK-84	102	158	.0000
0800	186	11	325300N	132259E	9001PF0197	Gas Turbine Powerplant; 1 Unit	t159		1	F-15E	4	GBU-24	102	159	.0000
0800	187	13	315200N	235500E	9003PF0198	Diesel Powerplant; 1 Unit	t161		1	F-15E	4	GBU-24	102	161	.0000
0800	188	14	245700N	101000E	9004PF0201	Electrical Switching Relay Station;	t162		1	F-16C	2	GBU-24	0	162	.9900
0800	189	14	245700N	101000E	9004PF0202	Transformer yard; 50000 sq meter	t163		1	F-15E	4	GBU-24	0	163	.9990
0800	190	14	245700N	101000E	9004PF0203	Thermal Powerplant; 1 Unit	t164		1	F-15E	4	GBU-24	0	164	.9990
0800	191	15	310400N	163459E	9002PF0204	Diesel Powerplant; 1 Unit	t165		1	F-15E	4	GBU-24	0	165	.9990
0800	192	15	310400N	163459E	9002PF0206	Transformer yard; 60000 sq meter	t167		3	F-15E	12	MK-84	0	167	.8749
0800	193	11	322059N	150459E	9002PF0209	Transformer yard; 56000 sq meter	t169		3	F-15E	12	MK-84	0	169	.8749
0800	194	16	270000N	142659E	9005PF0214	Electrical Switching Relay Station;	t173		1	F-16C	2	GBU-24	0	173	.9900
0800	195	11	324959N	131500E	9001PF0220	Diesel Powerplant; 1 Unit	t177		1	F-15E	4	GBU-24	102	177	.0000
0800	196	11	324959N	131500E	9001PF0222	Electrical Switching Relay Station;	1179		1	F-16C	2	GBU-24	102	179	.9900
0800	197	11	324959N	131500E	9001PF0223	Thermal Powerplant; 2 Units	t180		1	F-16C	2	GBU-24	102	180	.8399
0800	198	11	324959N	131500E	9001PF0224	Transformer yard; 250000 sq meter	t181		1	F-16C	2	GBU-24	102	181	.8399
0800	199	13	320459N	235500E	9003PF0219	Transformer yard; 150000 sq meter	t184		3	A-10A	12	MK-84	102	184	.0000
0800	200	11	325500N	120459E	9001PF0225	Diesel Powerplant; 1 Unit	t185		1	F-16C	2	GBU-24	0	185	.8399
0800	201	11	325500N	120459E	9001PF0427	"Petroleum Refinery and Terminal, 5	t186		1	F-16C	2	GBU-24	0	186	.8399
0800	202	11	325500N	120459E	9001PF0428	"Petroleum Storage, 15 Tanks"	t187		1	F-14D	4	GBU-16	0	187	.9084
0800	203	19	301500N	193459E	9002PF0430	"Petroleum Storage, 20 Tanks"	t189		1	A-10A	4	MK-84	0	189	.5999
0800	204	19	305500N	200700E	9003PF0420	"Petroleum Storage, 23 Tanks"	t197		1	A-10A	4	MK-84	0	197	.5999
0800	205	20	283000N	190000E	9002PF0425	"550 Km Pipeline, 4 pumping stations	t202		1	F-16C	2	GBU-24	0	202	.9900
0800	206	20	283000N	190000E	9002PF0426	"400 Km Pipeline, 4 pumping stations	t203		1	F-16C	2	GBU-24	0	203	.9900
0800	207	17	290700N	155100E	9002SF0263	"SAM Storage; 7 concrete bunkers, 16	t210		1	F-16C	2	GBU-24	0	210	.9900
0800	208	12	320659N	201659E	9003SF0269	"SAM/ammo Storage; 9 concrete bunker	t218		1	F-16C	2	GBU-24	102	218	.0000
0800	209	21	241059N	231900E	9006AB0002	23 Revetments	t252	INT	1	F-16C	2	GBU-24	0	252	.9900
0800	210	21	241059N	231900E	9006AB0003	8000 sq meters fuel storage	t253	INT	1	F-16C	2	GBU-24	0	253	.9900
0800	211	12	320659N	201659E	9003AB0008	20 Hardened Shelters	t258	INT	1	F-15E	4	GBU-24	102	258	.0000
0800	212	12	320659N	201659E	9003AB0010	8000 sq meters fuel storage	t260	INT	1	A-10A	4	MK-84	102	260	.7998
0800	213	13	315100N	235500E	9003AB0015	25 Hardened Shelters	t265	INT	1	F-15E	4	GBU-24	102	265	.0000
0800	214	13	315100N	235500E	9003AB0016	20 Revetments	t266	INT	1	A-10A	4	AGM-65	102	266	.8998
0800	215	13	315100N	235500E	9003AB0019	8 Maintenance buildings	t269	INT	1	F-117A	2	GBU-27	0	269	.9900

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION		MSN	#	AC	#	WPN	SEAD		.
0800	216	14	250759N	101059E	9004AB0030	11 Revetments	t273	INT	1	F-16C	2	GBU-24	0	273	.9900
0800	217	14	250759N	101059E	9004AB0031	8000 sq meters fuel storage	t274	INT	1	F-16C	2	GBU-24	0	274	.9900
0800	218	14	250759N	101059E	9004AB0032	2 Munitions storage bunkers	t275	INT	1	F-14D	4	GBU-16	0	275	.9744
0800	219	15	310459N	163459E	9002AB0058	21 Revetments	t280	INT	1	F-16C	2	GBU-24	0	280	.9900
0800	220	15	310459N	163459E	9002AB0059	4 acre fuel storage	t281	INT	1	F-16C	2	GBU-24	0	281	.9900
0800	221	15	310459N	163459E	9002AB0060	7 Munitions storage bunkers	t282	INT	1	F-14D	4	GBU-16	0	282	.9744
0800	222	11	322059N	150459E	9002AB0036	40 Hardened Shelters	t286	INT	1	F-15E	4	GBU-24	0	286	.9744
0800	223	11	322059N	150459E	9002AB0037	9 Revetments	t287	INT	1	F-16C	2	GBU-24	0	287	.9900
0800	224	11	322059N	150459E	9002AB0038	4 acre fuel storage	t288	INT	1	F-16C	2	GBU-24	0	288	.9900
0800	225	11	322859N	115259E	9001AB0044	32 Revetments	t294	INT	1	F-16C	2	GBU-24	0	294	.9900
0800	226	11	322859N	115259E	9001AB0045	4 acre fuel storage	t295	INT	1	F-16C	2	GBU-24	0	295	.9900
0800	227	11	324000N	130759E	9001AB0065	25 Revetments	t308	INT	1	A-10A	4	AGM-65	102	308	.8998
0800	228	11	324000N	130759E	9001AB0068	8 Maintenance buildings	t311	INT	1	F-117A	2	GBU-27	0	311	.9900
0800	229	11	325500N	131659E	9001AB0075	8 Maintenance buildings	t318	INT	1	F-117A	2	GBU-27	0	318	.9900
0800	230	12	320659N	200459E	9003SP0306	4 Docks; RORO Yes	t321		1	F-16C	2	GBU-24	102	321	.9900
0800	231	12	320659N	200459E	9003SP0307	10 Surface berths	t322		1	F-16C	2	GBU-24	102	322	.9900
0800	232	12	320659N	200459E	9003SP0308	6 Sub-Surface berths	t323		1	F-16C	2	GBU-24	102	323	.0000
0800	233	12	320659N	200459E	9003SP0309	4 Offloading cranes	t324		1	F-117A	2	GBU-27	0	324	.9900
0800	234	12	320659N	200459E	9003SP0434	6 Storage Buildings	t325		1	F-117A	2	GBU-27	0	325	.9900
0800	235	12	324500N	224000E	9003SP0320	2 Docks	t326		1	F-16C	2	GBU-24	102	326	.9900
0800	236	12	324500N	224000E	9003SP0321	19 Surface berths	t327		1	F-16C	2	GBU-24	102	327	.0000
0800	237	12	324500N	224000E	9003SP0322	2 Sub-Surface berths	t328		1	F-16C	2	GBU-24	102	328	.9900
0800	238	12	324500N	224000E	9003SP0323	1 Offloading crane	t329		1	F-117A	2	GBU-27	0	329	.9900
0800	239	12	324500N	224000E	9003SP0435	7 Storage Buildings	t330		1	F-117A	2	GBU-27	0	330	.9900
0800	240	11	321959N	151000E	9002SP0315	4 Civil docks	t331		1	F-16C	2	GBU-24	0	331	.9900
0800	241	11	325500N	131500E	9001SP0310	9 Docks	t332		1	F-16C	2	GBU-24	102	332	.9900
0800	242	11	325500N	131500E	9001SP0313	9 Offloading cranes	t335		1	F-117A	2	GBU-27	0	335	.9900
0800	243	11	325500N	131500E	9001SP0436	4 Storage Buildings	t337		1	F-117A	2	GBU-27	0	337	.9900
0800	244	13	320459N	240000E	9003SP0317	27 Surface berths	t339		1	F-16C	2	GBU-24	102	339	.9900
0800	245	13	320459N	240000E	9003SP0318	4 Sub-Surface berths	t340		1	F-16C	2	GBU-24	102	340	.9900
0800	246	13	320459N	240000E	9003SP0319	3 Offloading cranes	t341		1	F-117A	2	GBU-27	0	341	.9900
0800	247	13	320459N	240000E	9003SP0437	6 Storage Buildings	t342		1	F-117A	2	GBU-27	0	342	.9900
0800	248	12	320659N	200459E	9003SP0306	4 Docks; RORO Yes	t344		1	F-16C	2	GBU-24	102	344	.9900
0800	249	12	320659N	200459E	9003SP0307	10 Surface berths	t345		1	F-16C	2	GBU-24	102	345	.9900
0800	250	12	320659N	200459E	9003SP0308	6 Sub-Surface berths	t346		1	F-16C	2	GBU-24	102	346	.9900
0800	251	12	320659N	200459E	9003SP0309	4 Offloading cranes	t347		1	F-117A	2	GBU-27	0	347	.9900
0800	252	12	324500N	224000E	9003SP0320	2 Docks	t349		1	F-16C	2	GBU-24	102	349	.0000
0800	253	12	324500N	224000E	9003SP0321	19 Surface berths	t350		1	F-16C	2	GBU-24	102	350	.9900
0800	254	12	324500N	224000E	9003SP0322	2 Sub-Surface berths	t351		1	F-16C	2	GBU-24	102	351	.0000
0800	255	11	321959N	151000E	9002SP0315	4 Civil docks	t354		1	F-16C	2	GBU-24	0	354	.9900
0800	256	13	320459N	240000E	9003SP0316	4 Docks	t361		1	F-16C	2	GBU-24	102	361	.9900
0800	257	13	320459N	240000E	9003SP0317	27 Surface berths	t362		1	F-16C	2	GBU-24	102	362	.9900
0800	258	13	320459N	240000E	9003SP0318	4 Sub-Surface berths	t363		1	F-16C	2	GBU-24	102	363	.0000
0800	259	12	322700N	230700E	9003IA0228	SA-3	t368		1	F-16C	2	GBU-24	0	368	.9900
0800	260	12	322700N	230700E	9003IA0229	SA-2	t369		1	F-16C	2	GBU-24	0	369	.9900
0800	261	12	322700N	230700E	9003IA0395	EW Radar site; 8 buildings	t370		1	F-16C	2	GBU-24	0	370	.9900
0800	262	17	290700N	155100E	9002IA0230	SA-2	t375		1	F-16C	2	GBU-24	0	375	.9900
0800	263	12	320659N	201659E	9003IA0233	SA-3	t381		1	F-16C	2	GBU-24	102	381	.9900
0800	264	13	315200N	235500E	9003IA0235	SA-2	t385		1	F-16C	2	GBU-24	102	385	.9900
0800	265	14	250600N	101000E	9001IA0390	"GCI Radar site; 2 radars, 7 buildin	t389		1	F-16C	2	GBU-24	0	389	.9900
0800	266	16	270000N	142659E	9005IA0248	SA-2	t399		1	F-16C	2	GBU-24	0	399	.9900
0800	267	12	324500N	224000E	9003TI0347	"Cargo handling facility, 3 building	t418	INT	1	F-16C	2	MK-84	0	418	.0000
0800	268	12	320659N	200459E	9003MA0376	"Armor parking area,50000 sq meter"	t442	CAS	1	A-10A	4	AGM-65	102	442	.8998
1200	269	22	321000N	200459E	9003IA0388	"GCI Radar site; 1 radar, 4 building	t380		1	AV-8B	4	AGM-65	102	380	.8998

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION	MSN	#	AC	#	WPN	SEAD		
1200	270	22	320659N	201659E	9003IA0400	EW/GCI Radar site; 13 buildings t384		1	AV-8B	4	AGM-65	102	384	.8998
1200	271	23	302500N	193759E	9001IA0391	"GCI Radar site; 1 radar, 4 buildingt395		1	AV-8B	4	AGM-65	0	395	.8998
1200	272	24	320000N	240000E	9003IA0384	EW Radar site; 7 buildings t409		1	AV-8B	4	AGM-65	102	409	.8998
1200	273	24	320000N	240000E	9006IA0386	EW Radar site; 9 buildings t410		1	AV-8B	4	AGM-65	102	410	.8998
1200	274	25	325500N	131659E	9001IA0252	EW Radar site; 7 buildings t413		1	AV-8B	4	AGM-65	102	413	.8998
1600	275	26	323800N	141500E	9002PF0188	Electrical Switching Relay Station; t150		1	F-16C	2	GBU-24	0	150	.9900
1600	276	33	314959N	105500E	9001PF0210	Diesel Powerplant; 1 Unit t170		1	F-15E	4	GBU-24	0	170	.9990
1600	277	26	322859N	115259E	9001PF0211	Gas Turbine Powerplant; 1 Unit t171		1	F-15E	4	GBU-24	0	171	.9990
1600	278	26	322859N	115259E	9001PF0212	Transformer yard; 40000 sq meter t172		3	F-15E	12	MK-84	0	172	.8749
1600	279	30	270000N	142659E	9005PF0215	Transformer yard; 60000 sq meter t174		3	F-15E	12	MK-84	0	174	.8749
1600	280	28	311500N	163459E	9002PF0216	Gas Turbine Powerplant; 1 Unit t175		1	F-15E	4	GBU-24	0	175	.9990
1600	281	26	324759N	125500E	9001PF0226	Nuclear Power Production; 5 Units t176		1	F-15E	4	GBU-24	102	176	.0000
1600	282	27	320459N	235500E	9003PF0218	Thermal Powerplant; 1 Unit t183		1	F-15E	4	GBU-24	102	183	.0000
1600	283	29	304000N	181959E	9002PF0432	"Petroleum Storage, 28 Tanks" t191		1	A-10A	4	MK-84	0	191	.5999
1600	284	29	303000N	183459E	9002PF0433	"Petroleum Refinery and Terminal, 7 t192		1	F-16C	2	GBU-24	0	192	.8399
1600	285	29	303000N	183459E	9002PF0416	"Petroleum Storage, 20 Tanks" t193		1	A-10A	4	MK-84	0	193	.5999
1600	286	27	320000N	240459E	9003PF0418	"Petroleum Storage, 34 Tanks" t195		1	A-10A	4	MK-84	102	195	.5999
1600	287	35	274000N	223000E	9006PF0421	"500 Km Pipeline, 4 pumping stationst198		1	F-16C	2	GBU-24	0	198	.9900
1600	288	36	293000N	211000E	9006PF0422	"400 Km Pipeline, 3 pumping stationst199		1	F-16C	2	GBU-24	0	199	.9900
1600	289	29	305200N	200400E	9003SF0267	"Ammunition Storage; 9 earthen bunket214	INT	1	F-16C	2	GBU-24	0	214	.9900
1600	290	31	241059N	231900E	9006AB0001	25 Hardened Shelters t251	INT	1	F-15E	4	GBU-24	0	251	.9744
1600	291	31	241059N	231900E	9006AB0004	10 Munitions storage bunkers t254	INT	1	F-14D	4	GBU-16	0	254	.9744
1600	292	31	241059N	231900E	9006AB0005	4 Maintenance buildings t255	INT	1	F-14D	4	GBU-16	0	255	.9744
1600	293	31	241059N	231900E	9006AB0006	"2 Concrete RWY, 4 Asp TXWY" t256	INT	1	A-10A	4	MK-84	102	256	.4999
1600	294	31	241059N	231900E	9006AB0007	"2 Command bunkers, 13 Housing/Ops bt257	INT	1	F-15E	4	GBU-24	0	257	.9084
1600	295	29	320659N	201659E	9003AB0011	15 Munitions storage bunkers t261	INT	1	A-10A	4	MK-84	102	261	.7998
1600	296	29	320659N	201659E	9003AB0013	"2 Concrete RWY, 5 Asp TXWY" t263	INT	1	A-10A	4	MK-84	102	263	.4999
1600	297	29	320659N	201659E	9003AB0014	"2 Command bunkers, 15 Housing/Ops bt264	INT	1	F-15E	4	GBU-24	102	264	.0000
1600	298	27	315100N	235500E	9003AB0017	8000 sq meters fuel storage t267	INT	1	A-10A	4	MK-84	102	267	.7998
1600	299	27	315100N	235500E	9003AB0018	8 Munitions storage bunkers t268	INT	1	A-10A	4	MK-84	102	268	.7998
1600	300	27	315100N	235500E	9003AB0020	"3 Concrete RWY, 5 Asp TXWY" t270	INT	2	A-10A	8	MK-84	102	270	.7499
1600	301	27	315100N	235500E	9003AB0021	"1 Command bunker, 7 Housing/Ops buit271	INT	1	F-15E	4	GBU-24	102	271	.0000
1600	302	32	250759N	101059E	9004AB0029	30 Hardened Shelters t272	INT	1	F-15E	4	GBU-24	0	272	.9744
1600	303	32	250759N	101059E	9046AB0033	2 Maintenance buildings t276	INT	1	F-14D	4	GBU-16	0	276	.9744
1600	304	32	250759N	101059E	9004AB0034	"4 Asp RWY, 4 Asp TXWY" t277	INT	2	A-10A	8	MK-84	102	277	.0000
1600	305	32	250759N	101059E	9004AB0035	"1 Command bunker, 5 Housing/Ops buil278	INT	1	F-15E	4	GBU-24	0	278	.9084
1600	306	28	310459N	163459E	9002AB0057	30 Hardened Shelters t279	INT	1	F-15E	4	GBU-24	0	279	.9744
1600	307	28	310459N	163459E	9002AB0061	6 Maintenance buildings t283	INT	1	F-14D	4	GBU-16	0	283	.9744
1600	308	28	310459N	163459E	9002AB0062	"3 Concrete RWY, 4 Asp TXWY" t284	INT	2	A-10A	8	MK-84	102	284	.0000
1600	309	28	310459N	163459E	9002AB0063	"2 Command bunkers, 9 Housing/Ops but285	INT	1	F-15E	4	GBU-24	0	285	.9084
1600	310	26	322059N	150459E	9002AB0039	4 Munitions storage bunkers t289	INT	1	F-14D	4	GBU-16	0	289	.9744
1600	311	26	322059N	150459E	9002AB0040	4 Maintenance buildings t290	INT	1	F-14D	4	GBU-16	0	290	.9744
1600	312	26	322059N	150459E	9002AB0041	"2 Concrete RWY, 2 Asp TXWY" t291	INT	2	A-10A	8	MK-84	102	291	.0000
1600	313	26	322059N	150459E	9002AB0042	"2 Command bunkers, 6 Housing/Ops but292	INT	1	F-15E	4	GBU-24	0	292	.9084
1600	314	26	322859N	115259E	9001AB0043	37 Hardened Shelters t293	INT	1	F-15E	4	GBU-24	0	293	.9744
1600	315	26	322859N	115259E	9001AB0046	5 Munitions storage bunkers t296	INT	1	F-14D	4	GBU-16	0	296	.9744
1600	316	26	322859N	115259E	9001AB0047	5 Maintenance buildings t297	INT	1	F-14D	4	GBU-16	0	297	.9744
1600	317	26	322859N	115259E	9001AB0048	"2 Concrete RWY, 3 Asp TXWY" t298	INT	2	A-10A	8	MK-84	102	298	.7499
1600	318	26	322859N	115259E	9001AB0049	"1 Command bunker, 7 Housing/Ops buit299	INT	1	F-15E	4	GBU-24	0	299	.9084
1600	319	30	270000N	142559E	9005AB0050	25 Hardened Shelters t300	INT	1	F-15E	4	GBU-24	0	300	.9744
1600	320	30	270000N	142559E	9005AB0051	8 Revetments t301	INT	1	F-16C	2	GBU-24	0	301	.9900
1600	321	30	270000N	142559E	9005AB0052	12000 sq meters fuel storage t302	INT	1	F-16C	2	GBU-24	0	302	.9900
1600	322	30	270000N	142559E	9005AB0053	5 Munitions storage bunkers t303	INT	1	F-14D	4	GBU-16	0	303	.9744
1600	323	30	270000N	142559E	9005AB0054	5 Maintenance buildings t304	INT	1	F-14D	4	GBU-16	0	304	.9744

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TOT  MSN#  PKG   LAT     LON    BE#                    TARGET DESCRIPTION              MSN      # AC          # WPN      SEAD  1600 324
30 270000N 142559E 9005AB0055 "2 Concrete RWY, 3 Asp TXWY"         t305  INT      2 A-10A       8 MK-84      102  305  .0000
 1600 325    30 270000N 142559E 9005AB0056 "2 Command bunkers, 8 Housing/Ops but306  INT   1 F-15E      4 GBU-24       0  306  .9084
 1600 326    26 324000N 130759E 9001AB0064 35 Hardened Shelters              t307  INT   1 F-15E      4 GBU-24     102  307  .9744
 1600 327    26 324000N 130759E 9001AB0066 4 acre fuel storage               t309  INT   1 A-10A      4 MK-84      102  309  .7998
 1600 328    26 324000N 130759E 9001AB0067 19 Munitions storage bunkers      t310  INT   1 A-10A      4 MK-84      102  310  .7998
 1600 329    26 324000N 130759E 9001AB0069 "2 Concrete RWY, 3 Asp TXWY"      t312  INT   1 A-10A      4 MK-84      102  312  .4999
 1600 330    26 324000N 130759E 9001AB0070 "2 Command bunkers, 10 Housing/Ops bt313  INT   1 F-15E      4 GBU-24     102  313  .0000
 1600 331    26 325500N 131659E 9001AB0071 25 Hardened Shelters              t314  INT   1 F-15E      4 GBU-24     102  314  .9744
 1600 332    26 325500N 131659E 9001AB0072 27 Revetments                     t315  INT   1 A-10A      4 AGM-65     102  315  .8998
 1600 333    26 325500N 131659E 9001AB0073 4 acre fuel storage               t316  INT   1 A-10A      4 MK-84      102  316  .7998
 1600 334    26 325500N 131659E 9001AB0074 10 Munitions storage bunkers      t317  INT   1 A-10A      4 MK-84      102  317  .7998
 1600 335    26 325500N 131659E 9001AB0076 "2 Concrete RWY, 3 Asp TXWY"      t319  INT   1 A-10A      4 MK-84      102  319  .4999
 1600 336    26 325500N 131659E 9001AB0077 "1 Command bunker, 7 Housing/Ops buit320  INT   1 F-15E      4 GBU-24     102  320  .0000
 1600 337    26 325500N 131500E 9001SP0311 32 Surface berths                 t333        1 F-16C      2 GBU-24     102  333  .0000
 1600 338    26 325500N 131500E 9001SP0312 8 Sub-Surface berths              t334        1 F-16C      2 GBU-24     102  334  .9900
 1600 339    26 325500N 131500E 9001SP0314 6 Civil docks                     t336        1 F-16C      2 GBU-24     102  336  .0000
 1600 340    26 325500N 120459E 9001SP0324 2 Civil docks                     t343        1 F-16C      2 GBU-24       0  343  .9900
 1600 341    29 320659N 200459E 9003SP0434 6 Storage Buildings               t348        1 F-117A     2 GBU-27       0  348  .9900
 1600 342    27 324500N 224000E 9003SP0323 1 Offloading crane                t352        1 F-117A     2 GBU-27       0  352  .9900
 1600 343    27 324500N 224000E 9003SP0435 7 Storage Buildings               t353        1 F-117A     2 GBU-27       0  353  .9900
 1600 344    26 325500N 131500E 9001SP0310 9 Docks                           t355        1 F-16C      2 GBU-24     102  355  .9900
 1600 345    26 325500N 131500E 9001SP0311 32 Surface berths                 t356        1 F-16C      2 GBU-24     102  356  .9900
 1600 346    26 325500N 131500E 9001SP0312 8 Sub-Surface berths              t357        1 F-16C      2 GBU-24     102  357  .0000
 1600 347    26 325500N 131500E 9001SP0313 9 Offloading cranes               t358        1 F-117A     2 GBU-27       0  358  .9900
 1600 348    26 325500N 131500E 9001SP0314 6 Civil docks                     t359        1 F-16C      2 GBU-24     102  359  .0000
 1600 349    26 325500N 131500E 9001SP0436 4 Storage Buildings               t360        1 F-117A     2 GBU-27       0  360  .9900
 1600 350    27 320459N 240000E 9003SP0319 3 Offloading cranes               t364        1 F-117A     2 GBU-27       0  364  .9900
 1600 351    27 320459N 240000E 9003SP0437 6 Storage Buildings               t365        1 F-117A     2 GBU-27       0  365  .9900
 1600 352    26 325500N 120459E 9001SP0324 2 Civil docks                     t366        1 F-16C      2 GBU-24       0  366  .9900
 1600 353    27 324959N 213000E 9001IA0392 "GCI Radar site; 2 radars, 5 buildint371      1 F-16C      2 GBU-24       0  371  .9900
 1600 354    31 241059N 231900E 9006IA0385 SA-3                              t372        1 F-16C      2 GBU-24       0  372  .9900
 1600 355    31 241059N 231900E 9006IA0396 SA-5                              t373        1 F-16C      2 GBU-24       0  373  .9900
 1600 356    31 241059N 231900E 9006IA0397 EW Radar site; 8 buildings        t374        1 F-16C      2 GBU-24       0  374  .9900
 1600 357    28 290700N 155100E 9002IA0231 SA-3                              t376        1 F-16C      2 GBU-24       0  376  .9900
 1600 358    28 290700N 155100E 9002IA0398 EW Radar site; 8 buildings        t377        1 F-16C      2 GBU-24       0  377  .9900
 1600 359    28 290700N 155100E 9002IA0387 "GCI Radar site; 2 radars, 6 buildint378      1 F-16C      2 GBU-24       0  378  .9900
 1600 360    29 320659N 201659E 9003IA0234 SA-2                              t382        1 F-16C      2 GBU-24     102  382  .9900
 1600 361    29 320659N 201659E 9003IA0399 SA-5                              t383        1 F-16C      2 GBU-24     102  383  .9900
 1600 362    32 251000N 101000E 9004IA0239 SA-2                              t386        1 F-16C      2 GBU-24       0  386  .9900
 1600 363    32 251000N 101000E 9004IA0240 SA-3                              t387        1 F-16C      2 GBU-24       0  387  .9900
 1600 364    32 251000N 101000E 9004IA0382 EW Radar site; 6 buildings        t388        1 F-16C      2 GBU-24       0  388  .9900
 1600 365    28 310400N 163459E 9002IA0241 SA-2                              t390        1 F-16C      2 GBU-24       0  390  .9900
 1600 366    28 310400N 163459E 9002IA0242 SA-3                              t391        1 F-16C      2 GBU-24       0  391  .9900
 1600 367    27 324759N 215800E 9003IA0243 SA-2                              t392        1 F-16C      2 GBU-24       0  392  .9900
 1600 368    27 324759N 215800E 9003IA0244 SA-3                              t393        1 F-16C      2 GBU-24       0  393  .9900
 1600 369    27 324759N 215800E 9003IA0401 EW Radar site; 8 buildings        t394        1 F-16C      2 GBU-24       0  394  .9900
 1600 370    37 322059N 150459E 9002IA0245 SA-3                              t396        1 F-16C      2 GBU-24       0  396  .9900
 1600 371    37 322059N 150459E 9002IA0246 SA-2                              t397        1 F-16C      2 GBU-24       0  397  .9900
 1600 372    26 322859N 115259E 9001IA0247 SA-3                              t398        1 F-16C      2 GBU-24       0  398  .9900
 1600 373    30 270000N 142659E 9005IA0249 SA-3                              t400        1 F-16C      2 GBU-24       0  400  .9900
 1600 374    30 270000N 142659E 9005IA0402 EW Radar site; 7 buildings        t401        1 F-16C      2 GBU-24       0  401  .9900
 1600 375    28 311500N 163459E 9002IA0250 SA-5                              t402        1 F-16C      2 GBU-24       0  402  .9900
 1600 376    28 311000N 163459E 9001IA0393 "GCI Radar site; 1 radar, 4 buildingt403      1 F-16C      2 GBU-24       0  403  .9900
 1600 377    26 324000N 130759E 9001IA0253 SA-3                              t405        1 F-16C      2 GBU-24     102  405  .0000
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TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION	MSN	#	AC	#	WPN	SEAD		.
1600	378	26	324000N	130759E	9001IA0254	SA-2 t406		1	F-16C	2	GBU-24	102	406	.0000
1600	379	26	324000N	130759E	9001IA0255	SA-5 t407		1	F-16C	2	GBU-24	102	407	.9900
1600	380	26	325500N	131659E	9001IA0256	SA-3 t411		1	F-16C	2	GBU-24	102	411	.9900
1600	381	26	325500N	131659E	9001IA0257	SA-2 t412		1	F-16C	2	GBU-24	102	412	.0000
1600	382	29	320800N	200259E	9003TI0337	1 Bay Bridge t414	INT	1	F-16C	2	GBU-24	0	414	.0000
1600	383	29	320659N	200459E	9003TI0343	"Cargo handling facility, 9 buildingt415	INT	1	F-117A	2	GBU-27	0	415	.9900
1600	384	27	324500N	224000E	9003TI0347	"Cargo handling facility, 3 buildingt418	INT	1	F-16C	2	MK-84	0	418	.0000
1600	385	34	274959N	161959E	9005MA0352	"Troop barracks, 5 buildings" t431	CAS	1	F-14D	4	GBU-16	0	431	.9744
1600	386	34	274959N	161959E	9005MA0353	"Troop in open, 100000 sq meter" t432	CAS	1	F-15E	4	MK-84	0	432	.5999
1600	387	31	234959N	231000E	9006MA0360	"Troop in open, 50000 sq meter" t437	CAS	2	F-15E	8	MK-84	0	437	.8399
1600	388	29	320659N	200459E	9003MA0375	"Troop barracks, 10 buildings" t441	CAS	1	F-117A	2	GBU-27	0	441	.9900
1600	389	33	314959N	105500E	9001MA0365	"Troop barracks, 5 buildings" t443	CAS	2	F-15E	8	MK-84	0	443	.8399
1600	390	33	314959N	105500E	9001MA0366	"Armor parking area,150000 sq metert444	CAS	1	A-10A	4	AGM-65	102	444	.8998
1600	391	33	314959N	105500E	9001MA0367	"Artillery parking area,200000 sq mt445	CAS	1	A-10A	4	AGM-65	102	445	.8998
1600	392	30	270000N	142659E	9005MA0363	"Troop barracks, 5 buildings" t447	CAS	2	F-15E	8	MK-84	0	447	.8399
1600	393	30	270000N	142659E	9005MA0364	"Armor parking area, 300000 sq metet448	CAS	1	A-10A	4	AGM-65	102	448	.8998
1600	394	30	270000N	142659E	9005MA0371	"Vehicle parking, 200000 sq meter" t449	CAS	1	A-10A	4	AGM-65	102	449	.8998
1600	395	26	324000N	130759E	9001MA0373	"Troop barracks, 10 buildings" t450	CAS	1	F-117A	2	GBU-27	0	450	.9900
1600	396	26	324000N	130759E	9001MA0374	"Armor parking area, 150000 sq metet451	CAS	1	A-10A	4	AGM-65	102	451	.8998
1600	397	27	320459N	240000E	9003MA0556	"Troop barracks, 8 buildings" t452	CAS	1	F-117A	2	GBU-27	0	452	.9900
1600	398	27	320459N	240000E	9003MA0357	"Armor parking area,150000 sq metert453	CAS	1	A-10A	4	AGM-65	102	453	.8998
1600	399	27	320459N	240000E	9003MA0358	"Artillery parking area, 250000 sq t454	CAS	1	A-10A	4	AGM-65	102	454	.8998
1600	400	27	320459N	240000E	9003MA0359	"Vehicle parking, 160000 sq meter" t455	CAS	1	A-10A	4	AGM-65	102	455	.8998
1600	401	28	290700N	155100E	9002WM0326	Chemical Production; 5 Buildings t456		1	F-16C	2	GBU-24	0	456	.8399
1600	402	28	290700N	155100E	9002WM0327	Chemical Storage; 4 Hardened Bunkerst457		1	F-16C	2	GBU-24	0	457	.8399
1600	403	26	323800N	141500E	9002WM0330	Chemical Storage; 3 Hardened Bunkerst458		1	F-16C	2	GBU-24	0	458	.8399
1600	404	26	323800N	141500E	9002WM0331	Chemical Storage; 3 Hardened Bunkerst459		1	F-16C	2	GBU-24	0	459	.8399
1600	405	26	322500N	133000E	9001WM0329	"Chemical Production; 5 Buildings, 4t460		1	F-117A	2	GBU-27	0	460	.9900
1600	406	28	300700N	161300E	9002WM0333	Chemical Storage; 8 Hardened Bunkerst461		1	F-16C	2	GBU-24	0	461	.8399
1600	407	28	310400N	163459E	9002WM0332	Chemical Storage; 5 Hardened Bunkerst462		1	F-16C	2	GBU-24	0	462	.8399
1600	408	26	324759N	125500E	9001PF0325	Nuclear Research Facility; 4 Units t463		1	F-15E	4	GBU-24	102	463	.0000
1600	409	29	321959N	204959E	9003TB0403	"Garrison storage facility, 6 hardent470		1	F-16C	2	GBU-24	102	470	.0000
0000	0	0	250759N	101059E	9004AB0032	2 Munitions storage bunkers t025	INT	0	NONE	0	NONE	0	25	.0000
0000	0	0	324000N	130759E	9001AB0069	"2 Concrete RWY, 3 Asp TXWY" t132	INT	0	NONE	0	NONE	0	132	.0000
0000	0	0	304500N	201200E	9003SF0259	Vehicle Storage; 18000 sq meters t205	INT	0	NONE	0	NONE	0	205	.0000
0000	0	0	324500N	213000E	9003SF0288	"Supply Storage; 12 Wooden buildingst206	INT	0	NONE	0	NONE	0	206	.0000
0000	0	0	290700N	155100E	9002SF0260	"Ammunition Storage; 9 earthen bunket207	INT	0	NONE	0	NONE	0	207	.0000
0000	0	0	290700N	155100E	9002SF0261	"Supply Storage; 10 wooden buildingst208	INT	0	NONE	0	NONE	0	208	.0000
0000	0	0	290700N	155100E	9002SF0262	Vehicle Storage; 40000 sq meters t209	INT	0	NONE	0	NONE	0	209	.0000
0000	0	0	324000N	141159E	9002SF0264	"Ammunition Storage; 8 concrete bunkt211	INT	0	NONE	0	NONE	0	211	.0000
0000	0	0	324000N	141959E	9002SF0265	"Supply Storage; 4 wooden buildings,t212	INT	0	NONE	0	NONE	0	212	.0000
0000	0	0	323000N	205359E	9003SF0266	"Ammunition Storage; 13 concrete bunt213	INT	0	NONE	0	NONE	0	213	.0000
0000	0	0	321000N	200459E	9003SF0268	"Ammunition Storage; 8 earthen bunket216	INT	0	NONE	0	NONE	0	216	.0000
0000	0	0	321000N	200459E	9003SF0296	Vehicle Storage; 14000 sq meters t217	INT	0	NONE	0	NONE	0	217	.0000
0000	0	0	324500N	223459E	9003SF0283	"Supply Storage; 13 Wooden buildingst219	INT	0	NONE	0	NONE	0	219	.0000
0000	0	0	325500N	132500E	9001SF0284	"Supply Storage; 10 Wooden buildingst220	INT	0	NONE	0	NONE	0	220	.0000
0000	0	0	303459N	182700E	9002SF0277	"Ammunition Storage; 10 concrete bunt221	INT	0	NONE	0	NONE	0	221	.0000
0000	0	0	303459N	182700E	9002SF0290	"Supply Storage; 9 buildings, wide at222	INT	0	NONE	0	NONE	0	222	.0000
0000	0	0	315200N	235500E	9003SF0270	"Ammunition Storage; 4 convrete bunkt223	INT	0	NONE	0	NONE	0	223	.0000
0000	0	0	245700N	101000E	9004SF0286	"Supply Storage; 15 Wooden buildingst224	INT	0	NONE	0	NONE	0	224	.0000
0000	0	0	245700N	101000E	9004SF0305	"Food Storage; 8 buildings, 12000 sqt225	INT	0	NONE	0	NONE	0	225	.0000
0000	0	0	310400N	163459E	9002SF0272	"Ammunition Storage; 6 concrete bunkt226	INT	0	NONE	0	NONE	0	226	.0000
0000	0	0	310400N	163459E	9002SF0287	"Supply Storage; 7 Wooden buildings,t227	INT	0	NONE	0	NONE	0	227	.0000
0000	0	0	302500N	193759E	9002SF0273	"Ammunition Storage; 11 earthen bunkt228	INT	0	NONE	0	NONE	0	228	.0000

TOT	MSN#	PKG	LAT	LON	BE#	TARGET DESCRIPTION	MSN	#	AC	#	WPN	SEAD		
0000	0	0	302500N	193759E	9002SF0277	"Supply Storage; 9 Wooden buildings,t229	INT	0	NONE	0	NONE	0	229	.0000
0000	0	0	322059N	150459E	9002SF0274	"Ammunition Storage; 7 concrete bunkt230	INT	0	NONE	0	NONE	0	230	.0000
0000	0	0	322059N	150459E	9002SF0289	"Supply Storage; 9 buildings, wide at231	INT	0	NONE	0	NONE	0	231	.0000
0000	0	0	322859N	115259E	9001SF0275	"Ammunition Storage; 5 earthen bunket232	INT	0	NONE	0	NONE	0	232	.0000
0000	0	0	322859N	115259E	9001SF0276	"Ammunition Storage; 5 concrete bunkt233	INT	0	NONE	0	NONE	0	233	.0000
0000	0	0	270000N	142659E	9005SF0278	"Ammunition Storage; 8 concrete bunkt234	INT	0	NONE	0	NONE	0	234	.0000
0000	0	0	270000N	142659E	9005SF0297	Vehicle Storage; 50000 sq meters t235	INT	0	NONE	0	NONE	0	235	.0000
0000	0	0	311500N	163459E	9002SF0291	"Supply Storage; 7 Wooden buildings,t236	INT	0	NONE	0	NONE	0	236	.0000
0000	0	0	311500N	163459E	9002SF0298	Vehicle Storage; 18000 sq meters t237	INT	0	NONE	0	NONE	0	237	.0000
0000	0	0	325500N	131500E	9001SF0280	"Ammunition Storage; 13 earthen bunkt238	INT	0	NONE	0	NONE	0	238	.0000
0000	0	0	325500N	131500E	9001SF0302	"SAM Storage; 6 concrete bunkers, 15t239		0	NONE	0	NONE	0	239	.0000
0000	0	0	325500N	131500E	9001SF0293	"Supply Storage; 6 Wooden buildings,t240	INT	0	NONE	0	NONE	0	240	.0000
0000	0	0	325500N	131000E	9001SF0293	"Supply Storage; 9 Wooden buildings,t241	INT	0	NONE	0	NONE	0	241	.0000
0000	0	0	325500N	131000E	9001SF0300	Vehicle Storage; 30000 sq meters t242	INT	0	NONE	0	NONE	0	242	.0000
0000	0	0	325500N	131000E	9001SF0303	"Food Storage; 23 buildings, 40000 st243	INT	0	NONE	0	NONE	0	243	.0000
0000	0	0	320459N	235500E	9003SF0279	"Ammunition Storage; 7 earthen bunket244	INT	0	NONE	0	NONE	0	244	.0000
0000	0	0	320459N	235500E	9003SF0292	"Supply Storage; 17 Wooden buildingst245	INT	0	NONE	0	NONE	0	245	.0000
0000	0	0	320459N	235500E	9003SF0299	Vehicle Storage; 60000 sq meters t246	INT	0	NONE	0	NONE	0	246	.0000
0000	0	0	325300N	131659E	9001SF0281	"Ammunition Storage; 7 earthen bunket247	INT	0	NONE	0	NONE	0	247	.0000
0000	0	0	325300N	131659E	9001SF0294	"Supply Storage; 15 Wooden buildingst248	INT	0	NONE	0	NONE	0	248	.0000
0000	0	0	325500N	120459E	9001SF0282	"Ammunition Storage; 10 earthen bunkt249	INT	0	NONE	0	NONE	0	249	.0000
0000	0	0	325500N	120459E	9001SF0295	"Supply Storage; 16 Wooden buildingst250	INT	0	NONE	0	NONE	0	250	.0000
0000	0	0	320659N	200459E	9003TI0348	Sewage treatment facility t416	INT	0	NONE	0	NONE	0	416	.0000
0000	0	0	324500N	224000E	9003TI0341	Road constriction/choke point; 5km ht417	INT	0	NONE	0	NONE	0	417	.0000
0000	0	0	301000N	100000E	9001TI0338	Road constriction/choke point; 5 km t419	INT	0	NONE	0	NONE	0	419	.0000
0000	0	0	301000N	100000E	9001TI0340	Road constriction/choke point t420	INT	0	NONE	0	NONE	0	420	.0000
0000	0	0	321959N	151000E	9002TI0345	"Cargo handling facility, 95buildingt421	INT	0	NONE	0	NONE	0	421	.0000
0000	0	0	324500N	123000E	9001TI0339	Road constriction/choke point; 13km t424	INT	0	NONE	0	NONE	0	424	.0000
0000	0	0	325500N	131500E	9001TI0344	"Cargo handling facility, 9 buildingt425	INT	0	NONE	0	NONE	0	425	.0000
0000	0	0	325500N	131500E	9001TI0349	Sewage treatment facility t426	INT	0	NONE	0	NONE	0	426	.0000
0000	0	0	320459N	240000E	9003TI0342	Road constriction/choke point; 8km ht427	INT	0	NONE	0	NONE	0	427	.0000
0000	0	0	320459N	240000E	9003TI0351	Sewage treatment facility t429	INT	0	NONE	0	NONE	0	429	.0000
0000	0	0	294000N	211500E	9003TC0380	Terriorist Camp; 100000 sq meters t464		0	NONE	0	NONE	0	464	.0000
0000	0	0	264000N	124500E	9004TC0377	Terriorist Camp; 100000 sq meters t465		0	NONE	0	NONE	0	465	.0000
0000	0	0	302500N	131959E	9001TC0379	Terriorist Camp; 100000 sq meters t466		0	NONE	0	NONE	0	466	.0000
0000	0	0	283000N	171959E	9002TC0378	Terriorist Camp; 100000 sq meters t467		0	NONE	0	NONE	0	467	.0000
0000	0	0	290000N	155859E	9002TB0328	Launch Site (notional) t468		0	NONE	0	NONE	0	468	.0000
0000	0	0	310400N	163459E	9002TB0334	Launch Site (notional) t469		0	NONE	0	NONE	0	469	.0000
0000	0	0	325500N	131500E	9001TB0404	"Garrison storage facility, 3 hardent471		0	NONE	0	NONE	0	471	.0000
								460.00		996.00				

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Vita

Major William R. Haas was born on 15 January 1960 in Charleston, West Virginia. He graduated from Herbert Hoover High School in 1978 and entered the United States Air Force Academy for his undergraduate studies. He earned a Bachelor of Science degree in Civil Engineering and received his commission on 2 June 1982. Major Haas attended undergraduate pilot training at Williams AFB, Arizona where upon completion of his training, he was assigned as an A-10 pilot to the 510 TFS at RAF Bentwaters, UK. His following assignment was as the Assistant Director of Operations at the forward operating location located at Norvenich AB, FRG. Major Haas was selected to attend Fighter Weapons School in 1990 an upon graduation was assigned to the 355 FW as a Fighter Training Unit Instructor pilot. In 1994 he returned to the USAF Weapons School as an Instructor. He has completed Intermediate Service School and earned a Masters of Science degree in Aviation Science from Embry-Riddle Aeronautical University in 1995. In August 1996, Major Haas entered graduate studies at the Air Force Institute of Technology.

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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 98	Master's Thesis

4. TITLE AND SUBTITLE
AN OPERATIONAL REVIEW OF AIR CAMPAIGN PLANNING AUTOMATION

5. FUNDING NUMBERS

6. AUTHOR(S)
William R. Haas, Major, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology
2750 P Street
WPAFB OH 45433-7765t

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GOA/ENS/98M-04

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
POC: Dr. James W. Chrissis
DSN: 785-6565 x4338
e-mail: jchrissi@afit.af.mil

12a. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The air campaign planning process is a complex and dynamic process. Operations research has been applied to this problem to shorten the planning cycle with mixed results. The Joint Force Air Component Commander Planning Tool was developed as an air campaign planning aid. It uses the Conventional Targeting and Effectiveness Model (CTEM) as the force analysis model for master air attack plan (MAAP) planning. This thesis review the limitations and assumptions of CTEM and CTEM in JPT from and operational perspective. A new approach to using models in air campaign planning, collaborative planning, is being developed for use with JPT. This thesis reviews a pre-production version of the collaborative planning software, Advise, developed by AEM Services, Inc.

14. SUBJECT TERMS
Air Campaign Planning, Aerial warfare, Military Operations, Mathematical Models, Linear Programming

15. NUMBER OF PAGES
104

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL